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A CASE STUDY FOR THE DEVELOPMENT OF AN ISLAND FAUNA: RECENT TERRESTRIAL MOLLUSKS OF BERMUDA

Rüdiger Bieler[1] and John Slapcinsky[1,2]

ABSTRACT. The isolated western Atlantic island group of Bermuda provides a model case for the development of an island snail fauna. A unique combination of factors, such as an excellent Pleistocene fossil record, late (and precisely dated) human colonization, and extensive historic collecting and documentation efforts (last published in 1926), provide the background for this study. New field collecting, a survey of museum collections, and a critical review of published and unpublished information (resulting in several synonymies and reinterpretations of previously assumed endemics), were used to determine the presence and range of all terrestrial mollusks on Bermuda. At least 49 species of snails and slugs from 22 families are now known from Bermuda, including 11 endemic, 6 native non-endemic, 28 accidentally introduced and 4 intentionally introduced species.

Starting in 1958, several exotic predatory snails including *Gonaxis quadrilateralis* and *Euglandina rosea* were released in ill-advised attempts at biologically controlling the accidentally introduced snail species *Otala lactea* and *Rumina decollata*. *Euglandina rosea* is implicated in the extinction of several land snails native to the Pacific islands where it was also introduced. In Bermuda, densities of the three extant species in the endemic land snail genus *Poecilozonites* have been reported declining since the early 1960s and the group now appears to be nearly extinct. Individuals (or fresh shells) of two *Poecilozonites* species (*P. circumfirmatus* and *P. bermudensis*) were found although neither is common. This faunal survey finds *E. rosea* spread from its original release sites and generally distributed on the larger islands of Bermuda, with the possible exception of the

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[1] Department of Zoology, Field Museum of Natural History,
1400 S Lake Shore Drive, Chicago, Illinois 60605-2496,
U.S.A.; bieler@fmnh.org

[2] Current address: Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, U.S.A., slapcin@flmnh.ufl.edu

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southeastern corner of the main island. *Gonaxis* is beginning to spread beyond its release area. Several endemic and native non-endemic species including *P. reinianus*, *Vertigo marki*, *V. bermudensis*, and *Strobilops hubbardi* have only been found in the southeastern portion of the main island near caves and remnant native vegetation. The present study records three species new to Bermuda, *Tornatellides* sp., *Streptostele musaecola*, and *Opeas hannense*. *Zonitoides bermudensis*, previously recorded as an endemic species, is here synonymized with *Z. arboreus* and is recognized as a species introduced through human commerce. *Gastrocopta barbadensis crassilabris* is synonymized with *G. pellucida*, and recognized as a native non-endemic species. *Strobilops pilsbryi*, described as a species endemic to Bermuda, is synonymized with *S. hubbardi*. *Pupisoma macneilli*, *Punctum bristoli*, and *Striatura meridionalis*, previously known from Pleistocene fossils, are here recorded as members of Bermuda's extant fauna for the first time.

Key words: Bermuda, endemic, exotic, fauna development, land snails.

INTRODUCTION

Bermuda, a crescent-shape group of several large and numerous smaller western Atlantic islands, lies over 900 kilometers east of the nearest landfall at Cape Hatteras, North Carolina, and is among the most isolated island groups in the world. This remoteness is reflected in its depauperate native fauna (Wallace, 1895), especially by the near absence of non-avian vertebrates, represented by only one native species, the Bermuda Rock Skink, *Eumeces longirostris* (Cope, 1861).

Land snails are a major component of the native fauna and comprise nearly all of the Pleistocene fossils from terrestrial deposits (Gould, 1971b). Pulmonate snails are arguably among the most common and diverse animals on Bermuda. Previous authors (Pilsbry, 1900; Verrill, 1902) estimated the number of native species at 15 or 13 respectively (but, as will be shown below, included several species now known to be introduced through human commerce). Bermuda's land snail fauna is best known for its endemic zonitid genus, *Poecilozonites*. This group of several nominal extinct and extant species became the focus of numerous taxonomic, morphometric, and evolutionary studies (e.g., Peile, 1924, 1925; Kutchka, 1934; Pilsbry, 1934; Gould, 1966, 1968, 1970a,b, 1971a, b). The postulated rapid adaptive radiation of the *P. bermudensis* complex was cited as one of the two evidential examples for the Punctuated Equilibrium hypothesis (Eldredge & Gould, 1972), although the hypothesized evolutionary scenario for this "Darwin's finch among mollusks" (Gould, 1991: 12), based on ice-age climatic oscillations, has not remained undisputed (Brown, 1987; Glaubrecht, 1990).

The rich history of faunal surveys before 1926 has provided a remarkably complete picture of Bermuda's terrestrial snail fauna to that date. The lack of recently published surveys, the rapid decline of Bermuda's cedar forests, and the deliberate introductions of four species of predatory snails as agents of biological control make the current survey especially timely.

Bermuda was one of the few landmasses uninhabited by humans in Pre-Columbian times and was not settled until 1612. Late colonization and good written records have made the human-mediated changes to Bermuda's flora and fauna among the best documented of any region. Human intervention in Bermuda's ecosystem began long before settlement, in 1515, with the release of pigs by Bermudez who had discovered the islands in 1503. The first settlers, after 1612, added cats and dogs. Between 1614 and 1618, large populations of introduced rats, *Rattus rattus* (Linné, 1758), led to crop failures and the starvation of many colonists (Lefroy, 1876, cited from Verrill, 1902). Deliberate burns to eradicate the rats eliminated most of the already heavily logged primary cedar forest. Early last century, only a small tract of unburned native forest remained at Walsingham Jungle (Verrill, 1902). Several land snails appear to have been limited to this; however with only one previously published distributional study (Vanatta, 1911) among those merely recording "Bermuda," actual snail distributions in the island group were poorly known. This survey is the first since the remaining stands of the Bermuda cedar (*Juniperus bermudensis*) were severely damaged by scale blight, shortly after World War II.

Slightly east of the Gulf Stream (at 32°18'N, 64°46'W), Bermuda's climate is frost-free and mild, with about 1400 mm of evenly distributed rainfall annually. This mild climate has allowed the introduction and naturalization of many agricultural and ornamental plants, and with these, of numerous foreign plants and animals, including terrestrial mollusks. It is thus no surprise that many of today's non-native land snails in Bermuda are species commonly found associated with greenhouses and nurseries. Land snail introductions on Bermuda are particularly well documented with more than a dozen qualitative faunal surveys published between 1852 and 1926, leading Tomlin to assert "There is probably no island in the world that has been more thoroughly combed for non-marine shells than Bermuda" (1932: 98). Already by the time of the first faunal survey of Bermuda, at least six introduced species were present (Prime, 1853). By 1926, the date of the last published survey, at least 14 species of native and 22 species of introduced land snails inhabited Bermuda (Peile, 1926). During that 73-year period, little if any turnover in species had occurred. Each survey found nearly all but the smallest (< 3 mm) of the species previously recorded for the islands, despite the fact that many of these surveys were short and secondary to other projects.

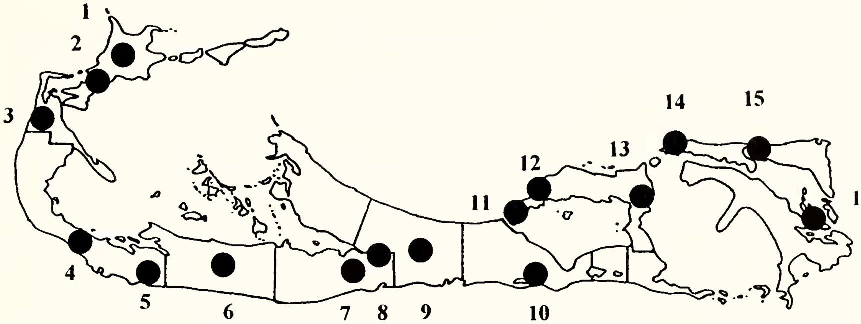
Pilsbry (1900) saw three origins for Bermuda's land snail fauna: (a) "Autocthonous species, peculiar to the islands," (b) "Drift waifs from the West Indies," and (c) "Species imported by the agency of man." We have categorized our records (and our interpretations of earlier records) in four different groups: (1) endemic species (species not known from elsewhere, and also present in Bermuda's good Pleistocene fossil record), (2) native, but not endemic, species (species that were present before the arrival of the first settlers), (3) accidentally introduced species, and (4) deliberately released species. Some of these might no longer have viable populations on the islands, as will be discussed below.

Several additional introductions have been recorded since the most recent faunal survey. *Rumina decollata* – an omnivorous snail now widely distributed in tropical and subtropical areas through human commerce – was originally native to the Mediterranean region and is considered a crop pest. This snail, introduced accidentally with plants in the late 1870s has become a widespread agricultural pest in Bermuda (Bennett & Hughes, 1959). In 1928, a second important horticultural pest was introduced. The Milk Snail *Otala lactea*, imported in 1928 for food, escaped and became naturalized (Bennett & Hughes, 1959). By the 1950s, the Bermuda Department of Agriculture was looking into methods to control these crop pests. With help from the Hawaiian Department of Agriculture several species of predatory snails were introduced in ill-fated attempts at controlling *Otala* and *Rumina* (Simmonds & Hughes, 1963). One of these predatory species, *Euglandina rosea*, is implicated in the extinction and endangerment of many land snails endemic to the Pacific Islands (Hadfield & Mountain, 1981; Clarke *et al.*, 1984; Murray *et al.*, 1989) and can also impact upon freshwater snails (Kinzie, 1992). The same fate might have befallen Bermuda's endemic genus *Poecilozonites*. Numbers of *Poecilozonites bermudensis* have been declining since the early 1960s (Gould, 1969, 1991).

The unique situation of Bermuda's historically well-documented land snail fauna provides an opportunity to track each species through recorded time – in several cases even establishing the exact event of first introduction. A complete bibliography for Bermuda land mollusks is also provided. This paper is part of an informal series on the terrestrial flora and fauna of Bermuda initiated by the Bermuda Department of Agriculture and Fisheries. Previous studies have included spiders (Sierwald, 1988), Coleoptera (Hilburn & Gordon, 1989), Lepidoptera (Ferguson *et al.*, 1991), and Diptera (Woodley & Hilburn, 1994).

MATERIALS AND METHODS

The core of the material for the present survey stems from intensive collecting efforts during one week in May of 1988. That survey involved three collectors (RB, Dr. Daniel Hilburn, Dr. Petra Sierwald), and most of the collecting sites are identical to those reported by Sierwald (1988) in a survey of Bermuda's spider fauna. Additional data originate from preliminary collections made by RB during a visit to the Bermuda Biological Station in 1983, from the



Map 1. Collecting localities.

collections previously held at the Department of Agriculture (now at the Natural History Museum, Bermuda), the Natural History Museum, Bermuda, and the Neil Fahy (Daly City, California) private collection.

Unique or questionable literature records were verified based on available voucher material, as indicated. In addition, Bermuda land snail holdings of the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, the California Academy of Sciences, the Delaware Museum of Natural History, the Field Museum of Natural History, the Florida Museum of Natural History, and the University of Michigan Museum of Zoology were studied. The existing literature on Bermuda land snails and all original species descriptions were researched, leading to new synonymies and re-interpretations of earlier records.

Maps: The distributions of all Recent species found on Bermuda are plotted using locality data from this survey and data from non-fossil museum specimens (see map 1 and museum collections studied).

This survey:

■ Closed squares:	Live specimens.
▣ Partly filled squares:	Recently dead specimens (with periostracum).
⊠ X-filled squares:	Long dead specimens.

Other records:

● Closed circles:	Museum specimens (nearly all collected prior to 1926), and in the case of the four deliberately introduced species (*Euglandina rosea*, *Gonaxis kibweziensis*, *G. quadrilateralis* and *Natalina cafra*) from surveys and annual reports of Bermuda's Department of Agriculture.
R	Release sites of deliberately introduced predatory snails.

Specimens collected during the 1983/1988 survey (map 1) are deposited at Field Museum of Natural History (FMNH 224755-224920 and 227001-227056), with duplicate voucher series deposited at BAMZ and DMNH.

1988 Survey sites:

01 Sandy's Parish	Gilbert Nature Reserve
02 Sandy's Parish	Fort Scaur
03 Sandy's Parish	Hog Bay Level
04 Southampton Parish	Seymour's Pond
05 Southampton Parish	Horseshoe Bay
06 Warwick Parish	Warwick Pond
07 Paget Parish	Que Sera Guesthouse
08 Paget Parish	Botanical Garden
09 Devonshire Parish	Devonshire Marsh
10 Smith's Parish	Spittal Pond
11 Hamilton Parish	Bermuda Aquarium
12 Hamilton Parish	Shelly Bay
13 Hamilton Parish	Walsingham Pond
14 St. George's Parish	Whalebone Bay
15 St. George's Parish	Mullet Bay Park
16 St. George's Parish	Smith's Island

Museum collections cited:

AMNH	American Museum of Natural History, New York
ANSP	Academy of Natural Sciences, Philadelphia
BAMZ	Bermuda Aquarium, Natural History Museum and Zoo
BPBM	Bernice P. Bishop Museum, Honolulu
CAS	California Academy of Sciences, San Francisco
DMNH	Delaware Museum of Natural History, Wilmington
FMNH	Field Museum of Natural History, Chicago
MCZ	Museum of Comparative Zoology, Cambridge
UF	Florida Museum of Natural History, Gainesville
UMMZ	University of Michigan Museum of Zoology, Ann Arbor

LIST OF RECENT BERMUDIAN TERRESTRIAL MOLLUSKS

The taxonomic arrangement in superfamilies and families follows Smith & Stanisic (1998) and Turgeon *et al.* (1998), respectively. In addition, Agriolimacidae Wagner, 1935 (see Wiktor, 2000), and Cochlicellidae Schileyko, 1972 (see Schileyko & Menkhorst, 1997) are used. Within superfamilies, families, genera, and species are each arranged alphabetically. The listings of synonyms and subsequent citations are restricted to records with relevance to Bermuda and those impacting taxonomic decisions. Species known from Bermuda only as fossils were not included. All species listed below were found in the current survey unless otherwise indicated.

Species were determined to be either (1) endemic to Bermuda, (2) native, but not endemic, (3) accidentally introduced by human activities, or (4) intentionally introduced for pest control. All native species are found in Bermuda's Pleistocene deposits which are among the best sampled and studied of their kind. Species missing from the fossil deposits are considered introduced. This assumption is reasonable in this case given that (1) all endemic species are found as fossils, (2) even uncommon or patchily distributed native non-endemic species are present in fossil deposits, and (3) most species without a fossil record in Bermuda are well known adventive species.

Distributions for all species on Bermuda were plotted using (1) new records from the present survey, (2) published surveys, especially that of Vanatta (1911), (3) museum and private collection records, including most voucher specimens of previous surveys, and (4) unpublished records of the Bermuda Department of Agriculture & Fisheries. The notes for each species include information about species ranges, habitat preferences, and method of introduction.

NERITIMORPHA: NERITOIDEA

HELICINIDAE

Oligyra convexa (Pfeiffer, 1849)

(Map 2, Fig. 1)

Helicina convexa Pfeiffer, 1849: 120-121 ("Locality unknown").

Helicina ---, - Redfield, 1853: 17;

Helicina variabilis, - Prime, 1853: 55; Jones, 1859: 107; Tristram, 1861: 405 [*non Helicina variabilis* Wagner in Spix, 1827: 25, pl. 16, figs. 3-4, Brazil];

Helicina subdepressa Poey, 1851: 420; - Jones, 1864: 9 [*non Helicina subdepressa* Poey, 1851];

Helicina convexa, - Bland, 1861: 351; Rein, 1867: 77; Mörch, 1878: 3; Bartram, 1878: 108; Kobelt, 1880: 286; Bland, 1881: 257; E. A. Smith, 1884: 277; Heilprin, 1889: 184; Bland, 1895: 271; Gulick, 1904: 421; Pilsbry, 1900: 506, pl. 62, figs. 15, 15a; Verrill, 1902: 728, fig. 69; Vanatta, 1911: 665-668; Honigmann, 1914: 377; Olmsted, 1917: 225; Vanatta, 1923: 33; Peile, 1926: 76 ["the only true land operculate in the islands"]; Hughes, 1968: 1;

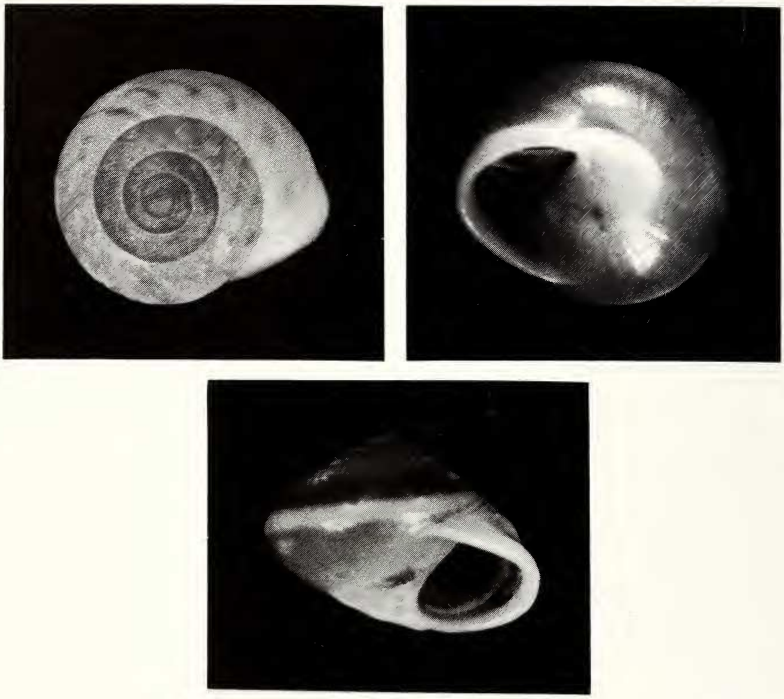
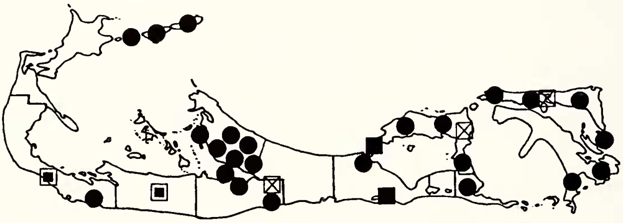


Figure 1. *Oligyra convexa.* – FMNH 29795, St. George's Parish, Bermuda; diameter = 7.7 mm (apical view); diameter = 7.4 mm (basal and apertural views).



Map 2. *Oligyra convexa.*

Helecina [*sic*] *convexa*, – Jones, 1876: 139;

Helicinia varibilis [*sic*], – Bartram, 1878: 108;

Helicina (Pachystoma) fasciata, – Angas, 1884: 597 [placed *H. convexa* in synonymy of *Helicina fasciata* Lamarck, 1822: 102 (type locality "Puerto Rico"; ? Guadeloupe, see van der Schalie, 1948: 21)];

Helix Convexus, – Lane, 1891: 1, pl. 2, fig. 9 [plate not seen];

Oligyra convexa, – Baker, 1922: 44 [based on material collected in Bermuda by Gulick in 1903];

Helicina fasciata convexa, – Wagner, 1911: 335, pl. 67, figs. 8, 9.

Helicina (Helicina) fasciata convexa, – Haas, 1952: 104.

Bermuda Material Studied: BAMZ 1994-118-006, 1995-132-023, 1998-166-021, 1998-166-034, 1998-166-049, 1998-166-066, 1998-166-068, 1998-166-080, 1998-166-104; DMNH 210240, 210265, 210270, 210328, 210330, 210331, 210333; FMNH 3624, 3625, 5473, 8835, 13485, 13499, 13510, 13521, 13528, 13541, 13548, 13552, 13560, 13563, 13567, 13571, 13574, 13576, 13594, 13683, 16465, 28193, 28615, 28769, 29795, 29796, 41737, 59081, 92869, 98243, 98251, 98286, 98317, 103289, 115079, 126379, 130912, 147968, 216085, 224764, 224778, 224795, 224796, 224820, 224833, 224880, 224897, 224911, 227019, 227025.

Note: *Accidentally Introduced* - One of the earliest introductions, this species was recorded for the year 1852 by Prime (1853) and by nearly every survey since. A very common species, it is found under rocks and on vegetation often in gardens and plantings. Hughes' (post 1969: 1) reference to fossil material is erroneous; the complete lack of helicinids in Bermuda's thoroughly investigated Pleistocene deposits suggests a more recent arrival. Bermuda's small high-spired helicinids are similar to forms found on the islands of the Lesser Antilles. Bermuda's early governors promoted the importation of exotic vegetation from other British colonies to provide food sources for early colonists (Verrill, 1902) and it is likely that this species was imported with these agricultural products. Revision of the West Indian helicinids is necessary before the source of *O. convexa* can be determined. The species was transferred to *Oligyra* by Baker (1922) based on characters of the radula and operculum.

BASOMMATOPHORA: ELLOBIOIDEA
CARYCHIIDAE
Carychium bermudense Gulick, 1904
(Map 3, Fig. 2)

Carychium bermudense Gulick, 1904: 415, pl. 36, figs. 11, 12 (Bermuda; fossil).

Carychium exiguum (Say, 1822) – Davis, 1904: 126 [*non Pupa exigua* Say, 1822: 375, which was cited by Pfeiffer, 1841b: 224. as *Carychium exiguum* "m[ihi]"];

Carychium bermudense, – Verrill, 1906: 171, figs. 54a, b (type specimen; fossil); Vanatta, 1924: 7; Gould, 1970b: 490, fig. 1h (fossil); Gould, 1970a: 572 (fossil);

Carychium bermudensis [*sic*], – Vanatta, 1911: 666-668; Vanatta, 1923: 33; Peile, 1926: 88.

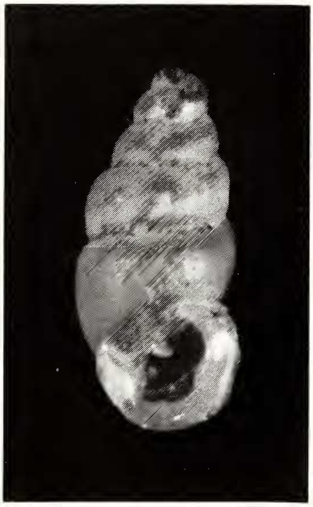


Figure 2. *Carychium bermudense.* – BAMZ 1995-133-003, Bermuda; height = 2.0 mm.

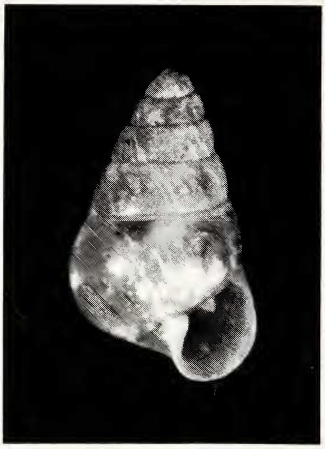
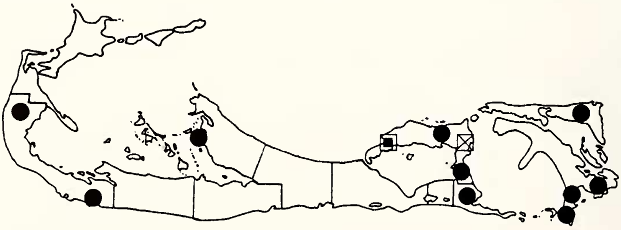


Figure 3. *Tornatellides* sp. – FMNH 227039, Sandy's Parish, Bermuda; height = 2.9 mm.

Bermuda Material Studied: ANSP 88559; BAMZ 1995-133-003; FMNH 30340, 227028, 227029; MCZ Gould Station 1 (fossil), Gould Station 11 (fossil), Gould Station 21 (fossil), Gould Station 21b (fossil), Gould Station 30 (fossil), Gould Station 41 east (fossil), Gould Station 48 (fossil).

Note: *Endemic* – This species was described from fossil material collected during expeditions sponsored by the then new Bermuda Biological Station (Gulick, 1904). Recent specimens were later collected by Stewerdson Brown (Vanatta, 1911). Specimens can be sifted from leaf litter, especially in the vicinity of marshland. The heavily callused and flared lip, tapered whorls, fine spiral striae, as well as the strongly dilated internal lamella which emerges strongly on the parietal wall and as a low basal thickening on the columellar wall, are similar to



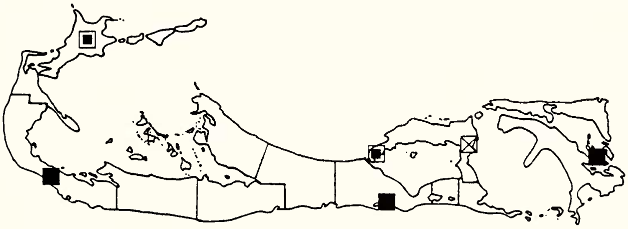
Map 3. *Carychium bermudense.*

Carychium mexicanum of the coastal region of southeastern North America; the relationship between the two nominal taxa needs further study.

STYLOMMATOPHORA: ACHATINELLOIDEA
ACHATINELLIDAE
Tornatellides sp. NEW RECORD
(Map 4, Fig. 3)

Bermuda Material Studied: BAMZ 1998-166-120, 1998-166-091, 1998-166-089, 1998-166-067, 1998-166-015; DMNH 210255, 210259, 210275, 210310; FMNH 224809, 224810, 227013, 227014, 227015, 227016, 227017, 227030, 227039.

Note: *Accidentally Introduced* – The genus *Tornatellides* is native to the Pacific Basin. This species (here treated as *Tornatellides* "sp." because of the current unresolved taxonomic situation of the genus) probably arrived in Bermuda sometime after the last faunal survey (Peile, 1926). It is now widespread on Bermuda and can be collected in great numbers from the bark of trees, suggesting possible importation through horticulture. This is the first record of this family in the Atlantic Basin.



Map 4. *Tornatellides* sp.

PUPILLOIDEA
PUPILLIDAE
Gastrocopta pellucida (Pfeiffer, 1841)
(Map 5, Fig. 4)

Pupa pellucida Pfeiffer, 1841a: 46 (Cuba).

? *Pupa bermudensis* Prime, 1853: 55 [*nomen nudum*];

Pupa jamaicensis C. B. Adams, 1849, – Bland, 1861: table 2, p. 351; Jones, 1876: 139; Kobelt, 1880: 286; Bland, 1881: 257; Bland, 1895: 271; Heilprin, 1889: 182 [*non Pupa jamaicensis* C. B. Adams, 1849];

? *Pupa Bermudensis* Jones, 1859: 107 [*nomen nudum*; based on Prime's list, but indicated as "n.s."];

Pupa pellucida, – Jones, 1876: 139; Kobelt, 1880: 286;

Pupa barbadensis, – Bland, 1881: 257; Bland, 1895: 271; Heilprin, 1889: 183 [*non Pupa barbadensis* Pfeiffer, 1853: 69 (Barbados)];

Pupa (Bifidaria) jamaicensis, – Pilsbry, 1900: 498 [*non* pl. 62, fig. 7 = *G. rupicola*]; Verrill, 1902: 729 [*non* fig. 74b];

Bifidaria jamaicensis, – Gulick, 1904: 415;

Bifidaria pellucida hordeacella (Pilsbry, 1890), – Vanatta, 1911: 665-668;

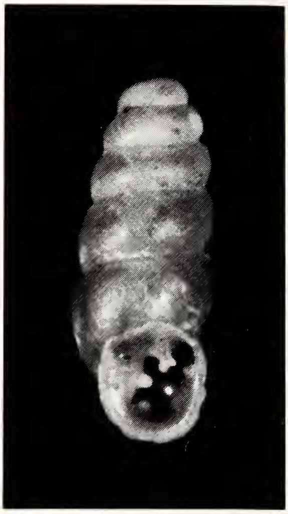


Figure 4. *Gastrocopta pellucida*. – FMNH 224832, Hamilton Parish, Bermuda; height = 2.6 mm.

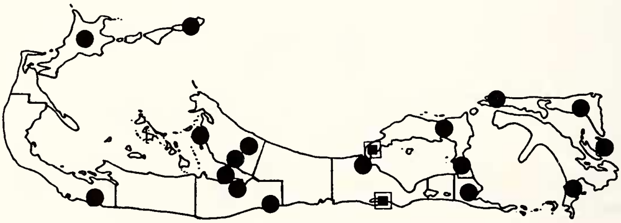
Gastrocopta barbadensis crassilabris Pilsbry, 1916: 85-86, pl. 18, figs. 6-9 (Bahamas and Bermuda), **new synonymy**;

Gastrocopta barbadensis crassilabris, – Peile, 1926: 88;

Gastrocopta barbadensis (Pfeiffer, 1853), – Vanatta, 1923: 33;

Gastrocopta pellucida hordeacella, – Vanatta, 1923: 33; Peile, 1926: 88; Gould, 1970b: 490, fig. 1b (fossil);

Gastrocopta (Gastrocopta) pellucida hordeacella, – Haas, 1952: 104.



Map 5. *Gastrocopta pellucida*.

Bermuda Material Studied: ANSP 3816, 143338; BAMZ 1995-133-008; FMNH 29802, 30201, 30203, 41009, 41010, 41011, 48647, 59074, 224832, 227040, 227048; MCZ Gould Station 4 (fossil), Gould Station 41 east (fossil), Gould Station 63 lower (fossil), Gould Station 73 (fossil); UMMZ 106756.

Note: *Native Non-Endemic* - This species ranges over much of the West Indies and North America from Florida north along the coast to New Jersey, west to southern California and southern Mexico. This and the following species are the most common *Gastrocopta* species on Bermuda and can be found on rocks in open areas. "*Pupa bermudensis*" probably refers to *Gastrocopta pellucida*, as the only material originally labeled "*Pupa bermudensis*" found in this study is a lot of *G. pellucida*, collected by A. D. Brown (ANSP 3816). *Gastrocopta pellucida* is extremely variable, not only in overall shell shape and size but also in the thickness of the peristome and apertural barriers, as was pointed out by Pilsbry (1916: 79). Several names have been applied to Bermuda's *Gastrocopta pellucida* depending on the thickness of the lamellae and peristome and the length of apertural plicae. These names include *Gastrocopta pellucida hordeacella* (for larger forms similar to those of the North American mainland with longer palatal plicae and a slight crest behind the lip), as well as forms misidentified as *G. barbadensis* (with thicker lamellae including a strongly bifid angulo-parietal barrier). Those specimens also having a thickened peristome have been described under the name *G. barbadensis crassilabris*. Pilsbry (1916: 85) stated: "In shape and size, *crassilabris* resembles *pellucida*, but the thick lip and the teeth are more like *marginalba*, the peristome being thicker and the crest stronger than in *barbadensis*." However, large series both from the North American mainland (FMNH 232835) and Bermuda (ANSP 143338) contain individuals that range from those similar to the holotype and paratypes of *pellucida hordeacella* (ANSP 60460) to individuals with stronger barriers and well developed bifid angulo-parietal teeth and thick peristomes that could be identified as *G. barbadensis crassilabris*. This variation is well illustrated by Vanatta (1912: plate 2; later reprinted by Pilsbry, 1948: fig. 495). Differences noted by Pilsbry between these nominal taxa, including the strength of the lamellae and plicae, the degree of bifurcation of the angulo-parietal lamellae, and the color differences between thin translucent yellowish shells and thicker brown shells can all potentially be caused by differences in calcium availability or by the age of individuals within a population. This view is supported by evidence of far greater changes in shell form due to differences in calcium availability within populations of other Bermuda species (Gould, 1970b, 1971a). The nominal subspecies *Gastrocopta barbadensis crassilabris* Pilsbry, 1916, is here synonymized under *G. pellucida*.

Gastrocopta rupicola (Say, 1821)
(Map 6, Fig. 5)

Pupa rupicola Say, 1821: 163 (East Florida).

Pupa pellucida Pfeiffer, 1841 (in part; see also G. *servilis*, below), – Bland, 1861: 351; Rein, 1867: 77; Bland, 1881: 257; Bland, 1895: 271; Jones, 1876: 139; Heilprin, 1889: 183 [*non Pupa pellucida* Pfeiffer, 1841];
Gastrocopta (Gastrocopta) barbadensis, – Haas, 1952: 104 [*non Pupa barbadensis* Pfeiffer, 1853];
Pupa (Bifidaria) rupicola, – Pilsbry, 1900: 498, pl. 62, figs.7 [*sic*], 8; Verrill, 1902: 729, figs. 4b [*sic*], 74c; Verrill, 1906: 170, fig. 68c;
Bifidaria rupicola, – Gulick, 1904: 414; Vanatta, 1911: 665-668; Vanatta, 1912: 12;
Gastrocopta rupicola duplex Pilsbry, 1916: 60, pl. 11, figs. 4, 7, 9 (Bermuda);
Pupa marginalba Pfeiffer, 1840: 253 (Cuba);
Gastrocopta rupicola marginalba (Pfeiffer, 1840), – Pilsbry, 1916: 61, pl. 11, figs. 10,11; Vanatta, 1924: 7; Peile, 1926: 88 (fossil);
Gastrocopta rupicola, – Vanatta, 1923: 33; Peile, 1926: 88; Gould, 1970a: 572 (fossil); Gould, 1970b: 490, fig. 1d (fossil);
Pupa rupicola, – Hughes, post 1969: 1;
Gastrocopta (Gastrocopta) rupicola, – Pilsbry, 1948: 905, 906.

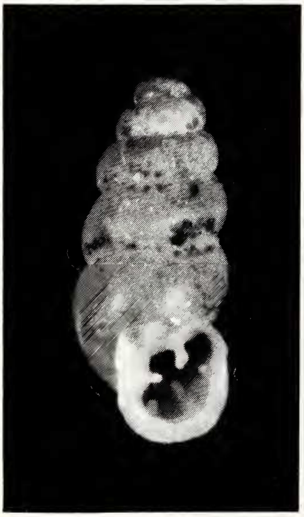
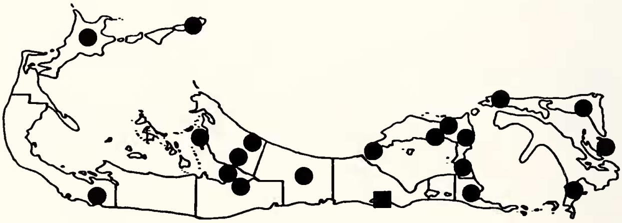


Figure 5. *Gastrocopta rupicola*. – FMNH 224805, Smith's Parish, Bermuda; height = 2.5 mm.



Map 6. *Gastrocopta rupicola*.

Bermuda Material Studied: BAMZ 1995-133-007; FMNH 30200, 41012, 59075, 224805, 224806, 227049; MCZ Gould Station 1 (fossil), Gould Station 4 (fossil), Gould Station 11 (fossil), Gould Station 21 (fossil), Gould Station 21b (fossil), Gould Station 30 (fossil), Gould Station 41 east (fossil), Gould Station 48 (fossil), Gould Station 63 lower (fossil), Gould Station 73 (fossil).

Note: *Native Non-Endemic* - This species is usually found in open, dry areas under rocks, often together with *Gastrocopta pellucida* and *Pupoides albilabris*. *Gastrocopta rupicola* ranges along the extreme southeastern coast of North America from North Carolina to Texas and the West Indies. Like the previous species it is widespread on Bermuda. Old individuals in calcareous areas often develop very thick lips, lamellae and plicae.

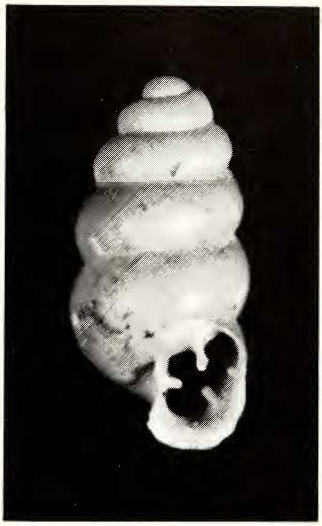
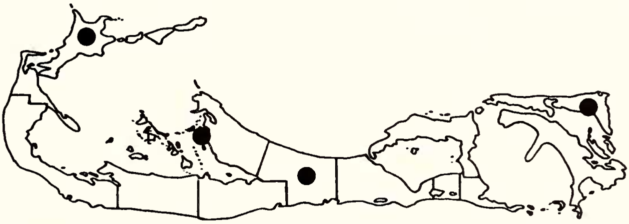


Figure 6. *Gastrocopta servilis.* - FMNH 30302, Devonshire Parish, Bermuda; height = 2.6 mm (lip chipped).

Gastrocopta servilis (A. A. Gould, 1843)
(Map 7, Fig. 6)

Pupa servilis Gould, 1843: 356, pl. 16, fig. 14 (Mexico).

Pupa pellucida Pfeiffer, 1841 (in part; see also G. *rupicola*, above), - Bland, 1861: 351; Bland, 1881: 257; Bland, 1895: 271; Heilprin, 1889: 183 [non *Pupa pellucida* Pfeiffer, 1841];



Map 7. *Gastrocopta servilis.*

Pupa (Bifidaria) servilis, - Pilsbry, 1900: 497, pl. 62, fig. 6; Verrill, 1906: 169-170, fig. 68a; Verrill, 1902: 729, fig. 74a;

Bifidaria servilis, - Gulick, 1904: 414; Vanatta, 1911: 665-668;

Gastrocopta servilis, - Peile, 1926: 88.

Bermuda Material Studied: FMNH 30202.

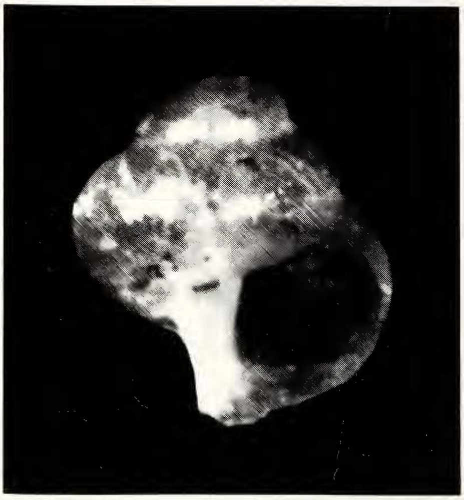


Figure 7. *Pupisoma macneilli*. - FMNH 227043, Hamilton Parish, Bermuda; height = 1.08 mm (aperture damaged).

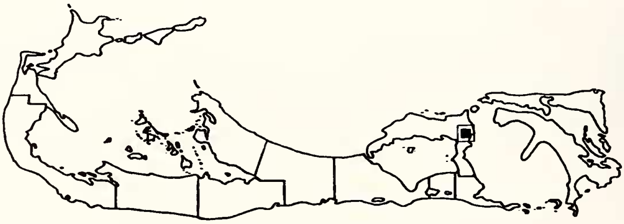
Note: *Accidentally Introduced* - Gulick (1904: 414) reported a single fossil specimen from Bermuda. However, no additional records were recorded by Gould (1970b) or located in his samples from stations 4, 41, and 48. Gulick's record is likely due to contamination with Recent material as this common Neotropical species has been widely introduced through commerce (Hubricht, 1985).

Pupisoma macneilli (Clapp, 1918) NEW EXTANT RECORD
(Map 8, Fig. 7)

Thysanophora macneilli Clapp, 1918: 74, pl. 8, fig.1 (Alabama).

Pupisoma sp., - Gould, 1970b: 490 (fossil).

Bermuda Material Studied: FMNH 227043; MCZ Gould Station 4 (fossil),



Map 8. *Pupisoma macneilli*.

Gould Station 11 (fossil), Gould Station 41 east (fossil), Gould Station 48 (fossil), Gould Station 73 (fossil). This present study records the first Recent specimens of this species for Bermuda (fresh specimens with periostracum, collected in surface sand samples from Walsingham Pond; FMNH 227043). Also studied was the *Pupisoma* material as cited by Gould (1970b: 490).

Note: *Native Non-Endemic* - This widespread Neotropical species ranges from the southeastern United States to Central and South America and the West Indies. *Pupisoma macneilli* can be found on smooth-barked tree trunks and under leaves (Hubricht, 1985: 12). *Pupisoma* was first recorded from Bermuda by Gould (1970b) from Pleistocene deposits. Material examined from Gould stations 4, 41, and 48 (S. J. Gould research collection, specimens not individually numbered or sorted) are here identified as *P. macneilli*.

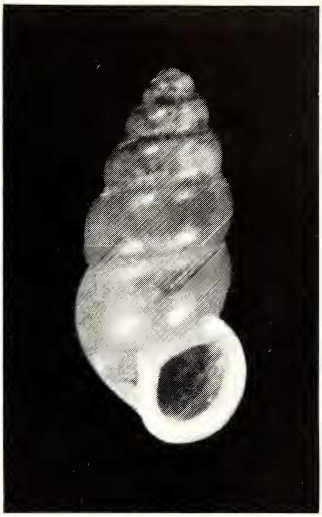
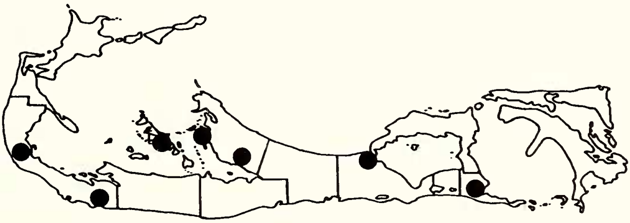


Figure 8. *Pupoides albilabris*. - BAMZ 1995-132-004, Bermuda; height = 4.6 mm.

Pupoides albilabris (C. B. Adams, 1841)
(Map 9, Fig. 8)

Pupa albilabris C. B. Adams, 1841 [new name for *Cyclostoma marginata* Say, 1821: 172-173, *non Cyclostoma marginatum* G. Fischer, 1807: 219] (Cuba).



Map 9. *Pupoides albilabris*.

Bulimus nitidulus Pfeiffer, 1839: 352 (Cuba) [not to be confused with *Bulimulus nitidulus* Beck, 1837: 67];
? *Bulimus Sandysii* Prime, 1853: 55 [*nomen nudum*];
? *Bulimus Sandysii* Jones, 1859: 107 [*nomen nudum*; based on Prime's list, but indicated as "n.s."];
Bulimus nitidulus, - Bland, 1861: table 2, p. 351; Rein, 1867: 77; Bland, 1881: 256; Bland, 1895: 271;
Pupa fallax Say, 1825, - Jones, 1876: 139; Bartram, 1878: 108;
Bulimulus fallax Say (*nitidulus* Pfr.), - Kobelt, 1880: 286;
Pupoides fallax, - Heilprin, 1889: 183;
Pupoides marginatus (Say, 1821), - Pilsbry, 1900: 498, pl. 62, fig. 16; Verrill, 1902: 729, fig. 73; Gulick, 1904: 415; Vanatta, 1911: 666-668; Peile, 1926: 89 [*non Pupa marginata* Draparnaud, 1801: 58; *nec Cyclostoma marginata* G. Fischer, 1807; see Pilsbry, 1948: 923];
Pupoides (Pupoides) albilabris, - Pilsbry, 1948: 921;
Pupoides albilabris, - Gould, 1970b: 490, fig. 1c (fossil);
Pupoides nitidulus, - Abbott, 1989: 64, fig.

Bermuda Material Studied: BAMZ 1995-132-004; Gould Station 63 lower (fossil), Gould Station 73 (fossil).

Note: *Native Non-Endemic - Pupoides albilabris* ranges over much of eastern and southern North America from southeastern Canada to Mexico (Pilsbry, 1948) and has been introduced in California (Hanna, 1966). It is a calciphile often found in glades and other open areas (Hubricht, 1985). This species appears to be patchily distributed on Bermuda (Jones, 1876, recorded it as rare) and was not found in this survey.

Vertigo bermudensis Pilsbry, 1919
(Map 10, Fig. 9)

Vertigo bermudensis Pilsbry, 1919: 149, pl. 13, figs. 8-10, 12 (Bermuda).

Vertigo eyriesii (Drouët, 1859), - Vanatta, 1911: 666 [*non Pupa eyriesii* Drouët, 1859];
Vertigo bermudensis, - Peile, 1926: 89.

Bermuda Material Studied: ANSP 91159, 105610; BAMZ 1995-132-001.

Note: *Endemic* - To date, the only specimens of this species with verifiable data were collected in the early 1900s from the vicinity of Church Cave near Tuckerstown. Pilsbry (1919: 149, 150) compared this species to the similar *Vertigo milium* (Gould, 1840) of eastern North America.

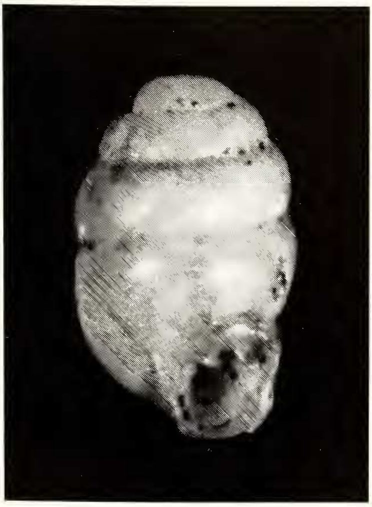


Figure 9. *Vertigo bermudensis*. - BAMZ 1995-132-001, Bermuda; height = 1.3 mm.

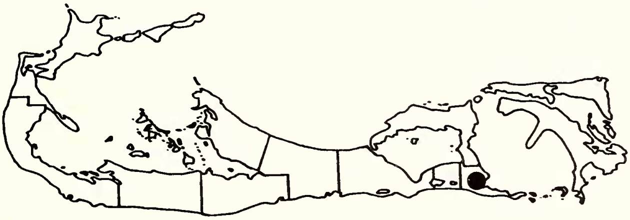
Vertigo marki Gulick, 1904 (Map 11, Fig. 10)

Vertigo marki Gulick, 1904: 414, pl. 36, fig. 7 (Bermuda, fossil).

Vertigo marki, - Verrill, 1906: 170, fig. 54d (type; fossil); Vanatta, 1911: 666; Pilsbry, 1919: 107, pl. 13, fig. 17; Peile, 1926: 89 (fossil); Gould, 1970b: 490 (fossil).

Bermuda Material Studied: ANSP 85574, 91156; BAMZ 1995-132-002; MCZ Gould Station 4 (fossil).

Note: *Endemic* - This species has never been documented alive, although empty Recent shells are recorded from leaf litter around Church Cave (Pilsbry, 1919). This species is believed to be most closely related to *Vertigo tridentata* Wolf, 1870, of eastern North America (Pilsbry, 1919).



Map 10. *Vertigo bermudensis*.

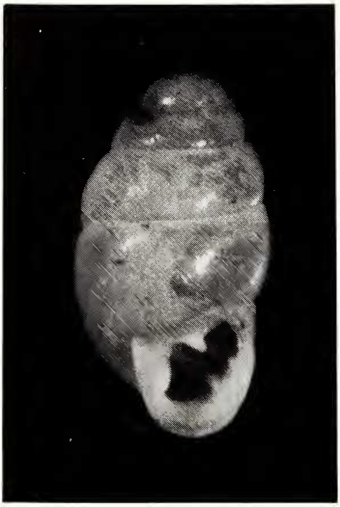


Figure 10. *Vertigo marki.* – BAMZ 1995-132-002, Bermuda; height = 2.2 mm.

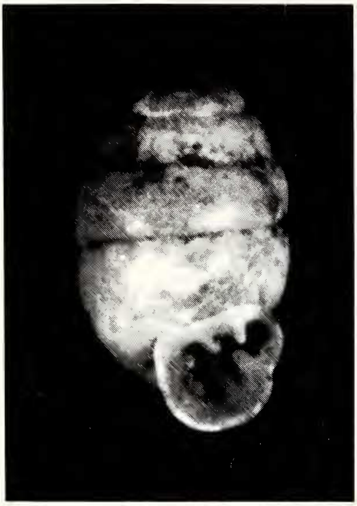


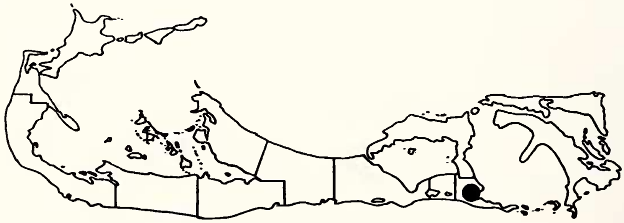
Figure 11. *Vertigo numellata.* – ANSP 105611, Hamilton Parish, Bermuda; height = 1.7 mm.

Vertigo numellata Gulick, 1904
(Map 12, Fig. 11)

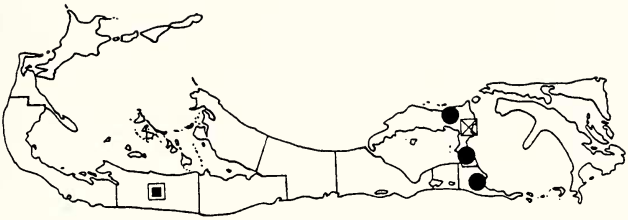
Vertigo numellata Gulick, 1904: 413-414, pl. 36, fig. 6 (Bermuda, fossil).

Vertigo numellata, – Verrill, 1906: 170, fig. 54c (type); Vanatta, 1911: 666; Pilsbry, 1919: 91, pl.13, figs. 14, 15; Vanatta, 1924: 7; Peile, 1926: 88; Hughes, post 1969: 1; Gould, 1970b: 490, fig. 1e.

Bermuda Material Studied: ANSP 85583, 91158, 105611, 85583; BAMZ 1995-132-003; FMNH 224903; MCZ Gould Station 1 (fossil), Gould Station 4 (fossil),



Map 11. *Vertigo marki.*



Map 12. *Vertigo numellata.*

Gould Station 11 (fossil), Gould Station 21 (fossil), Gould Station 21b (fossil), Gould Station 30 (fossil), Gould Station 41 east (fossil), Gould Station 48 (fossil), Gould Station 63 lower (fossil), Gould Station 73 (fossil).

Note: *Endemic* - Originally described from fossil material, this is the most common living *Vertigo* species on Bermuda. Recent specimens were first reported by Vanatta (1911) from collections by Stewerdson Brown (ANSP 91158). Although previously considered similar to *Vertigo oralis* Sterki, 1898 (Pilsbry, 1919), and *V. ovata* Say, 1822 (Gulick, 1904), the strong contraction and large oblique crest behind the shell aperture as well as the long lower palatal fold indicate this species' close affinity with *V. bermudensis*. Both *V. numellata* and *V. bermudensis* have been collected around caves and not along the margins of wetlands as would be expected of *V. oralis* or *V. ovata*. Shells of *V. numellata* differ only slightly from those of *V. bermudensis*, having less deeply impressed sutures, larger size and a stronger basal fold.

STROBILOPSIDAE

Strobilops hubbardi (A. D. Brown, 1861)

(Map 13, Fig. 12)

Helix Hubbardi A. D. Brown, 1861: 333, figs. 1, 2 (Texas).

Strobilops hubbardi, - Gulick, 1904: 413 (fossil); Verrill, 1906: 169 ("not known as a recent shell in Bermuda"); Vanatta, 1911: 666; Vanatta, 1912: 12; Vanatta, 1924: 7; Peile, 1926: 89 (fossil); Pilsbry, 1948: 865-868; Gould, 1970b: 490, fig. 1g (fossil).

Strobilops pilsbryi Morrison, 1953: 53-54, pl. 6, figs. 1-3 (Bermuda), **new synonymy.**

Bermuda Material Studied: BAMZ 1995-133-009; FMNH 227033; MCZ Gould Station 4 (fossil), Gould Station 21b (fossil), Gould Station 30 (fossil), Gould

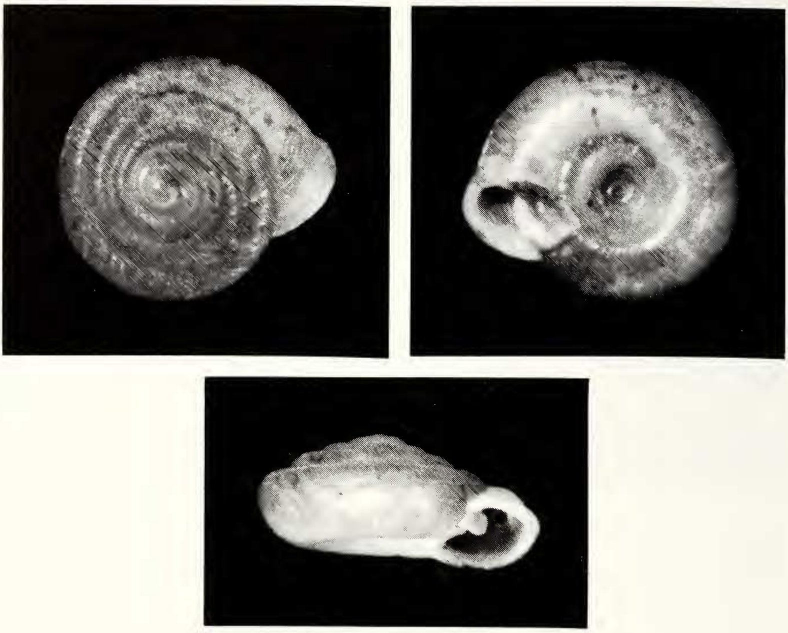
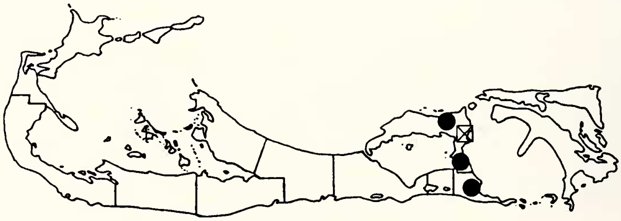


Figure 12. *Strobilops hubbardi.* - BAMZ 1995-133-009, Bermuda; diameter = 2.7 mm.

Station 41 east (fossil), Gould Station 63 (fossil); USNM 251195 (paratypes of *Strobilops pilsbryi*). Only one empty shell was located in this latest survey (FMNH 226908, Walsingham Pond).

Note: *Native Non-Endemic* - This species ranges over southeastern North America from coastal Georgia south to Central America and east to Jamaica, Cuba and the Bahamas (Pilsbry, 1948).

Adult *Strobilops hubbardi* specimens from Bermuda usually have four basal



Map 13. *Strobilops hubbardi.*

lamellae and a weak columellar lamella. Morrison (1953), citing the presence of this columellar lamella, larger shell size and umbilical width, described *Strobilops pilsbryi* as endemic to Bermuda. However, mainland populations of *Strobilops hubbardi* also contain individuals with such lamellae (UF 110589). Furthermore, there is ontogenetic variation in the number and strength of lamellae in *Strobilops hubbardi* (UF 110593). Only the second and fourth basal lamellae are found in many immature individuals (see Pilsbry, 1948, p. 849, for numbering and terminology of *Strobilops* lamellae). Four lamellae are found in most adults, however some adults do not develop all lamellae (see Pilsbry, 1948, fig. 468). The columellar lamella is the smallest and latest lamella to develop. The prevalence of this structure in the Bermuda populations is likely due to the high calcium content of many of Bermudas soils allowing complete and pronounced development of apertural barriers.

This species is usually found on rotting logs and branches in open woods.

VALLONIIDAE

Vallonia pulchella (Müller, 1774)

(Map 14, Fig. 13)

Helix pulchella Müller, 1774: 30-31 (Europe).

? *Helix paludosa* da Costa, 1778: 59 [see Gerber, 1996: 68; Gerber erroneously stated "Locus typicus?"; however, da Costa (1778: 59) clearly indicated several localities in Britain, "in Oxendon and Arthingworth, in Northamptonshire"];
? *Helix palludosa* [*sic*; no author given], - Prime, 1853: 55; Jones, 1859: 106 [citing Prime];
? *Helix paludosus* Say [*sic*]—Tristram, 1861: 405;
Helix putchella [*sic*] Müller, - Rein, 1867: 77;
Helix pulchella, - Jones, 1876: 138; Bland, 1881: 256; Bland, 1895: 271;
Helix (Vallonia) pulchella, - Heilprin 1889: 182;
Vallonia pulchella, - Sterki, 1893: 278; Pilsbry, 1900: 495; Verrill, 1902: 732, 733, fig.; Bryant, 1905: 129-130; Vanatta, 1911: 665-666; Peile, 1926: 89; Pilsbry, 1948: 1023-1025; Glaubrecht, 1990: 218; Gerber, 1996: 56 [based on Pilsbry, 1948].

Bermuda Material Studied: BAMZ 1995-132-005.

Note: *Accidentally Introduced* - "*Helix paludosa*" of Prime's (1853) list and "*Helix paludosus*" Say of Tristram's list (1861) probably refer to this species rather than to

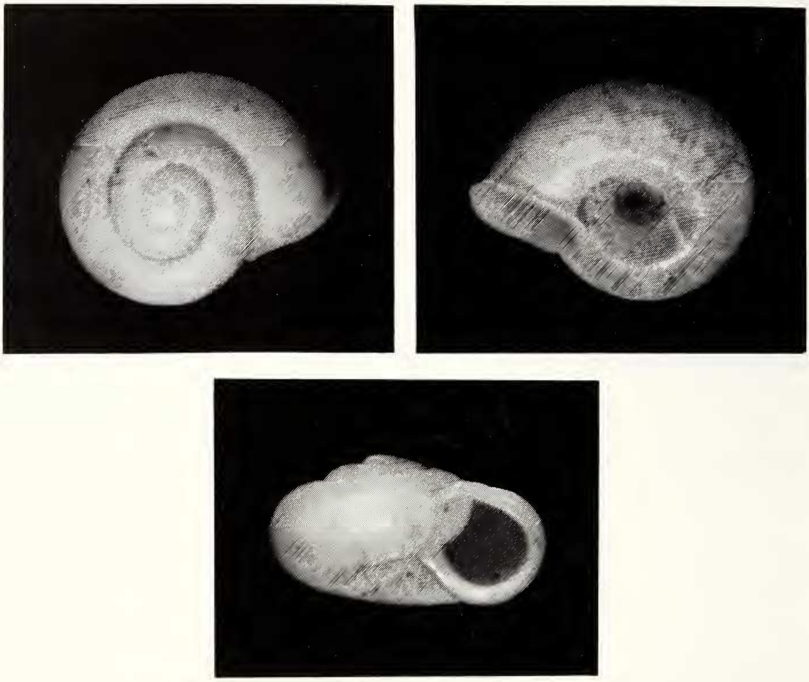
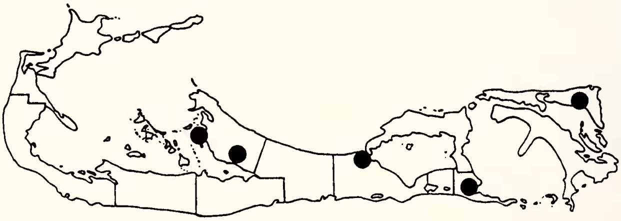


Figure 13. *Vallonia pulchella.* - BAMZ 1995-132-005, Bermuda; diameter = 2.3 mm.

Polygyra plana (Dunker, 1843) as surmised by Pilsbry (1900). The source of this confusion stems from Prime's omission of the species authority for his record of *Helix paludosa.* Tristram later amended Prime's record to *paludosus* and erroneously attributed it to Say. Unfortunately, *H. paludosa* has two homonyms: *Helix paludosa* Pfeiffer, 1839, was associated with *Polygyra plana* (Dunker, 1843) by Pilsbry (1900: 506), while *Helix paludosa* da Costa, 1778, is a synonym of *Vallonia excentrica* Sterki, 1893, a species very similar to and often confused with *V. pulchella.* Both *Vallonia pulchella* and *Polygyra plana* are found on Bermuda. Pilsbry may have overlooked *H.*



Map 14. *Vallonia pulchella.*

paludosa da Costa when he concluded that the early authors were looking at *Polygyra plana*. This view is supported by the fact that Tristram recorded both *paludosa* and *microdonta* (see *Polygyra plana* synonymy).

Vallonia excentrica ranges over much of the Northern Hemisphere. In North America it is native to the Northeast from southern Ontario (Oughton, 1948) to Missouri (Hubricht, 1985), and has been introduced to Texas, New Mexico, the Rocky Mountain States, California, and Oregon (Bequaert & Miller, 1973). It is found in open areas including meadows, marshes and sand dunes (Kerney & Cameron, 1979), as well as on roadsides and lawns (Hubricht, 1985), usually under cover of boards, wood or on house foundations and other cement structures.

ACHATINOIDEA

FERUSSACIIDAE

Cecilioides acicula (Müller, 1774)

(Map 15, Fig. 14)

Buccinum acicula Müller, 1774: 150-151 (Europe).

Bulimus acicula, - Bland, 1861: table 2;
Achatina acicula, - Bland, 1861: 351;
Cionella acicula, - Jones, 1876: 139; Bartram, 1878: 108; Bland, 1881: 256;
Caecilianella acicula, - Kobelt, 1880: 257, 286; Glaubrecht, 1990: 218.
Caecilianella (Cionella) acicula, - Heilprin, 1889: 183;
Coecilianella acicula, - Bland, 1895: 271;

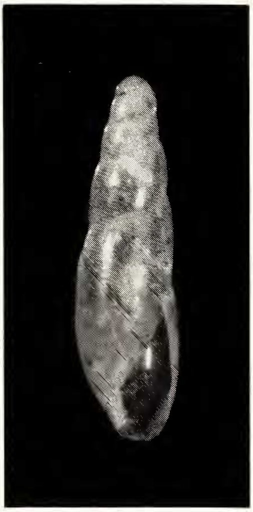
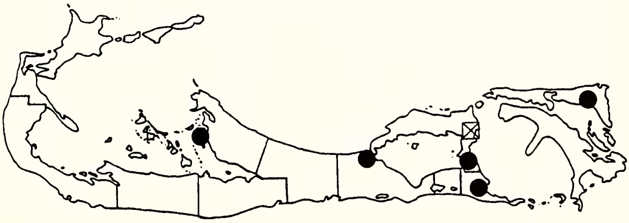


Figure 14. *Cecilioides acicula*. - BAMZ 1995-133-002, Bermuda; height = 4.3 mm.



Map 15. *Cecilioides acicula*.

Cecilioides acicula, – Bryant, 1905: 130; Pilsbry, 1946: 185, 186;

Caecilioides acicula, – Pilsbry, 1900: 497; Verrill, 1902: 731, 732, fig. 78a; Vanatta, 1911: 665-667; Peile, 1926: 90; Abbott, 1989: 84, fig.

Bermuda Material Studied: BAMZ 1995-133-002; FMNH 227024.

Note: *Accidentally Introduced* - First recorded in Bermuda by Bland in 1861, this small snail is native to Europe. Its burrowing habits might explain the small number of collection records on Bermuda and its easy transport between greenhouses and plant nurseries across the world.

SPIRAXIDAE

Euglandina rosea (Férussac, 1821)

(Map 16, Fig. 15)

Helix (Cochlicopa) rosea Férussac, 1821: 50 [or p. 54, depending on issue] (Florida).

Euglandina rosea, – Bennett & Hughes, 1959: 432; Hughes, 1962; Hughes, 1963; Simmonds & Hughes, 1963: 219 ff.; Hughes, post 1968: 1; Monkman, 1982a: 1; Monkman, 1982b: 71; Cock, 1985: 138; Glaubrecht, 1990: 221, fig. 11.

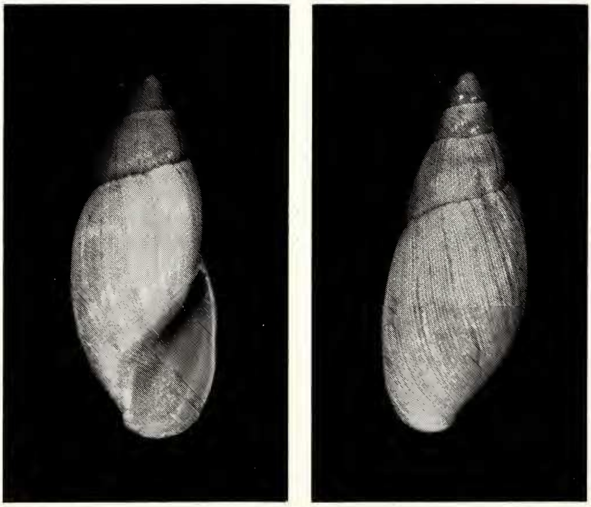
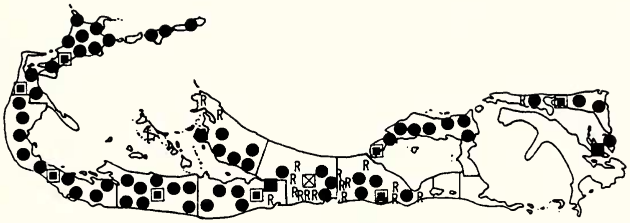


Figure 15. *Euglandina rosea*. – left: BAMZ 1994-118-010, Pembroke Parish, height = 48.6 mm; right: FMNH 224776, Paget Parish, Bermuda, height = 50.0 mm.



Map 16. *Euglandina rosea.*

Bermuda Material Studied: BAMZ 1998-166-002, 1998-166-005, 1998-166-026, 1998-166-039, 1998-166-046, 1998-166-051; DMNH 210302, 210308, 210316, 210323, 210338; FMNH 224761, 224792, 224814, 224831, 224844, 224853, 224855, 224861, 224866, 224869, 224879, 224896, 224905, 224913, 224920, 227001.

Note: *Intentionally Introduced* - This native of the southeastern United States was introduced on many islands of the Pacific as a biological control against the agricultural pest snail *Achatina fulica. Euglandina rosea* specimens – mostly from Florida (Davis & Butler, 1964), not from Cuba as stated by Cock (1985) – were released in the Hawaiian Islands in 1955 and were established there by 1957 (Krauss, 1964). In 1958, the Bermuda Department of Agriculture received a shipment of about 50 adult *Euglandina rosea* from Hawaii via the West Indian Station CIBC (Commonwealth Institute of Biological Control) in Trinidad to breed and release in efforts to control *Otala lactea* and, secondarily, *Rumina decollata*, two accidentally introduced horticultural pests. Later that year, after brief tests to ascertain that *Euglandina* would consume *Rumina*, *Otala* and other local snails when captive with them, *Euglandina rosea* was released on Bermuda. Between January and April of 1958, 329 snails were released, and by 1960, a total of 841 animals had been set free (Hughes, 1962 unpubl.). Releases of specimens received via Hawaii and Trinidad continued for a few more years. By 1962, the Department of Agriculture reported "excellent control of *Otala lactea* [had] been achieved." At that time, *E. rosea* had become so abundant that the Department exported nearly 1,000 specimens to various countries, ranging from the Bahamas to India (Hughes, 1962 unpubl.). Although ultimately failing to control either *Otala* or *Rumina*, *Euglandina* has become widespread in Bermuda and might be responsible for the decline of several of Bermuda's native snails, including the members of the now nearly extinct endemic genus *Poecilozonites*.

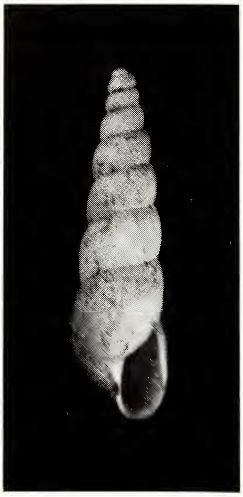


Figure 16. *Allopeas gracile.* - FMNH 227044, Sandy's Parish, Bermuda; height = 10.8 mm.

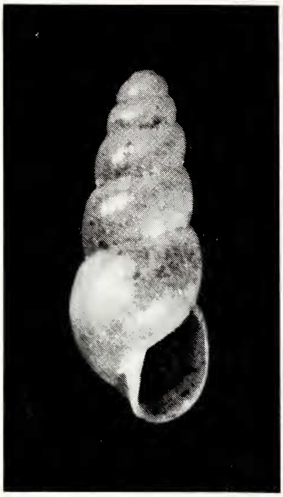


Figure 17. *Allopeas micrum.* - FMNH 30195, St. George's Parish, Bermuda; height = 6.3 mm.

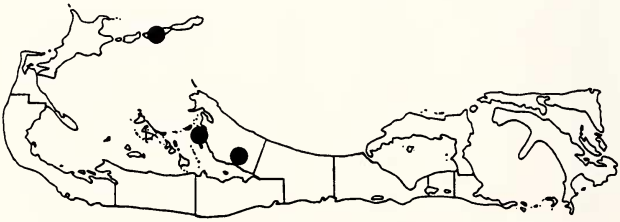
SUBULINIDAE

Allopeas gracile (Hutton, 1834)

(Map 17, Fig. 16)

Bulimus? gracilis Hutton, 1834: 84, 93 (India).

Opeas gracile, - Vanatta, 1911: 666-667; Peile, 1926: 90;
Opeas (Opeas) gracile, - Haas, 1952: 104;
Allopeas gracile, - Naggs, 1992: 258-259; ICZN, 1994: 162-163; Naggs, 1994: 187.



Map 17. *Allopeas gracile.*

Bermuda Material Studied: BAMZ 1994-118-016; FMNH 227044.

Note: *Accidentally Introduced* - Probably originally from the Neotropical region (Solem, 1964: 134), *Allopeas gracile* has been introduced worldwide in cultivated areas of the tropics and in greenhouses and was first described from India. Deisler & Abbott (1984: 13) stated that this "species probably is the most widely distributed land snail." In North America, this species is found from South Carolina to Texas (Karlin & Naegele, 1966; Dundee, 1970).

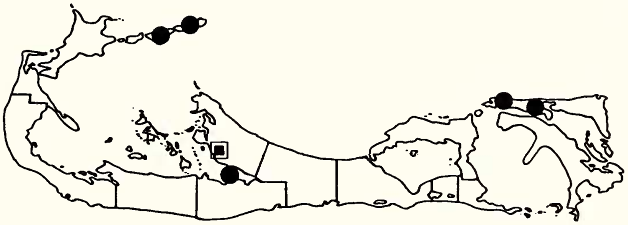
Allopeas micrum (Orbigny, 1835)
(Map 18, Fig. 17)

Helix micra Orbigny, 1835: 9 (Central America).

Opeas octonoides (C. B. Adams, 1845), - Pilsbry, 1900: 497; Verrill, 1902: 732 [*Bulimus octonoides* C. B. Adams, 1845, *non Bulimus octonoides* Orbigny in Sagra, 1841];
Opeas micra, - Vanatta, 1911: 666-667; Peile, 1926: 90;
Opeas (Opeas) micrum, - Haas, 1952: 104.

Bermuda Material Studied: FMNH 30194, 30195.

Note: *Accidentally Introduced* - Probably native to Central America, the West Indies, and northern South America, this species has been introduced into the southeastern United States and the Bahamas (Deisler & Abbott, 1984). On Bermuda, *Allopeas micrum* was first collected by the Heilprin party in 1888, but not included in their publication of 1889 (Pilsbry, 1900). This species is often found near greenhouses and in urban areas.



Map 18. *Allopeas* ***micrum***.

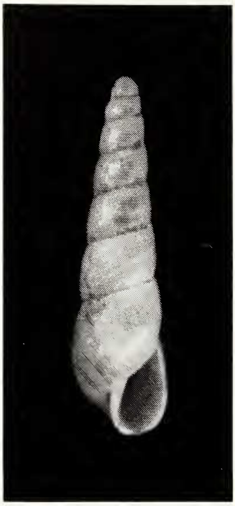


Figure 18. *Opeas hannense*. – FMNH 278023, St. George's Parish, Bermuda; height = 9.2 mm.

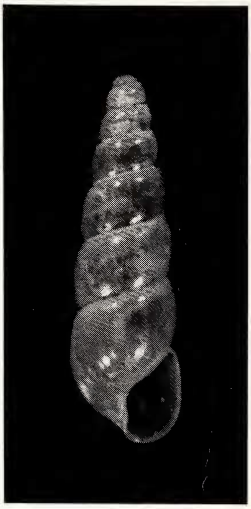


Figure 19. *Obeliscus swiftianus*. – FMNH 30197, St. George's Parish, Bermuda; height = 7.3 mm.

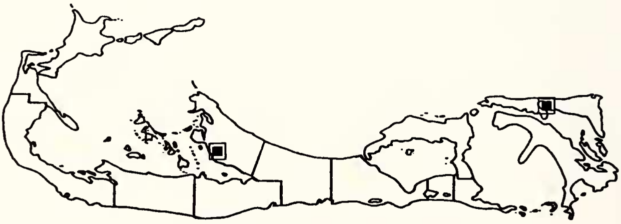
Opeas hannense **(Rang, 1831)** **NEW RECORD**

(Map 19, Fig. 18)

Helix hannensis Rang, 1831: 41-42, pl. 3, fig. 8 (Cape Vert peninsula, Senegal).

Opeas hannensis [*sic*] (Rang, 1831), – Proschwitz, 1983: 283; Proschwitz, 1994: 184.

Bermuda Material Studied: FMNH 278023 (Mullet Bay Park), 227034 (city of Hamilton).



Map 19. *Opeas hannense*.

Note: *Accidentally Introduced* - A native of the New World tropics, this species is now widely distributed. In North America it has been introduced to southern Florida and greenhouses in New York, Pittsburgh and Chicago (Pilsbry, 1946). *Bulimus pumilus* Pfeiffer, 1840, first described from Cuba, is a synonym (Proschwitz, 1994: 184). This species is here recorded from Bermuda for the first time.

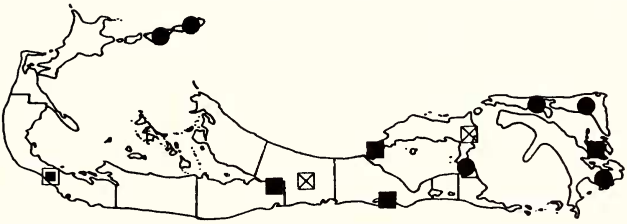
Obeliscus swiftianus (Pfeiffer, 1852)
(Map 20, Fig. 19)

Bulimus Swiftianus Pfeiffer, 1852: 150 (St. Thomas).

Opeas swiftianum, – Pilsbry, 1900: 497, pl. 62, fig.5; Verrill, 1902: 731, 732, fig. 78;
Obeliscus swiftianus, – Vanatta, 1911: 665; Vanatta, 1923: 33; Peile, 1926: 90.

Bermuda Material Studied: BAMZ 1998-166-004, 1998-166-018, 1998-166-024, 1998-166-031, 1998-166-045, 1998-166-077, 1998-166-082, 1998-166-085, 1998-166-086, 1998-166-087; DMNH 210251, 210252, 210264, 210278, 210282; FMNH 3632, 13493, 29794, 30197, 224773, 224811, 224812, 224822, 224835, 224846, 224857, 224863, 227023, 295082.

Note: *Accidentally Introduced* - Like the previous two species, *Obeliscus swiftianus* is native to the American tropics and has been widely distributed through commerce. This species was collected by the Heilprin expedition but not included in their 1889 publication (Pilsbry, 1900). *Obeliscus swiftianus* is usually found under cover in urban areas and near horticulture.



Map 20. *Obeliscus swiftianus*.

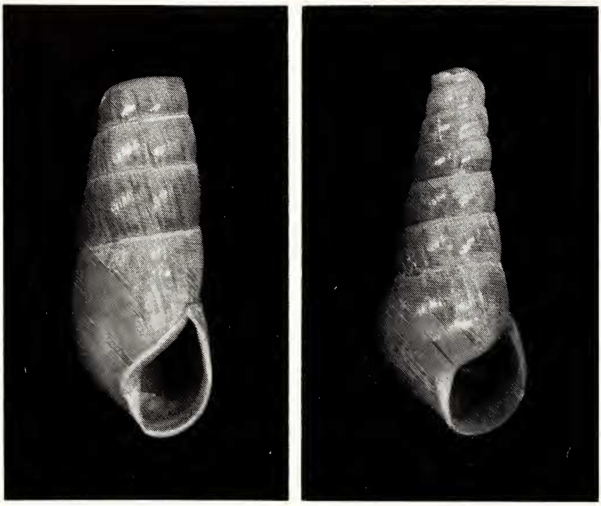
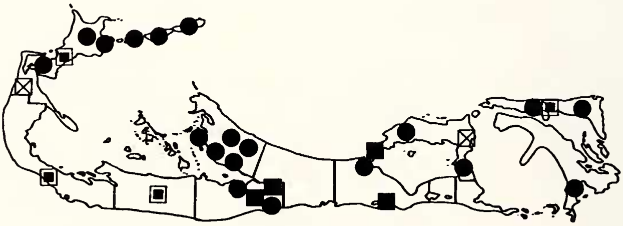


Figure 20. *Rumina decollata*. - FMNH 224777; Paget Parish, Bermuda; left: height = 28.5 mm; right (subadult): diameter = 18.4 mm.

Rumina decollata (Linné, 1758)
(Map 21, Fig. 20)

Helix decollata Linné, 1758: 773 (Europe).

Subulina decollata, - Bartram, 1878: 108;
Bulimulus decollatus, - Heilprin, 1889: 183; Frith, 1891: 14; Peniston, 1891: 21;
Stenogyra decollata, - Aldrich, 1889: 9; Lane, 1891: 3; Bland, 1895: 271;



Map 21. *Rumina decollata*.

Rumina decollata, – Riley & Howard *in* Hastings, 1892: 334; Johnson, 1900: 117; Pilsbry, 1900: 496; Verrill, 1902: 730, 731, figs. 75a-c, 76a, b, 79e; Vanatta, 1911: 665-668; H. H. Smith, 1912: 4; Honigmann, 1914: 376; Vanatta, 1923: 33; Peile, 1926: 90; Pilsbry, 1946: 170-172; Bennett & Hughes, 1959: 432; Simmonds & Hughes, 1963: 219-220; Monkman, 1982a: 1; Monkman, 1982b: 71; Bennett et al., 1985: 138; Cock, 1985: 138.

Bermuda Material Studied: BAMZ 1998-166-007, 1998-166-013, 1998-166-040, 1998-166-058, 1998-166-062, 1998-166-065, 1998-166-076, 1998-166-099, 1998-166-105, 1998-166-108, 1998-166-110; DMNH 210271, 210294, 210300, 210313, 210324, 210337; FMNH 3630, 8670, 8836, 13501, 13527, 13531, 13537, 13556, 13582, 13591, 13679, 13686, 16473, 16474, 29793, 41014, 112230, 135326, 216093, 224755, 224762, 224793, 224794, 224826, 224839, 224870, 224889, 224900, 224907, 227057, 227008, 227009, 227027.

Note: *Accidentally Introduced - Rumina decollata*, a ground dweller, is often found in gardens and orchards and is among the most common of Bermuda's snails. *Rumina decollata* is a common pest species introduced worldwide to subtropical areas, and is well established in the southern U.S. (Dundee, 1970). This native of the Mediterranean region is believed to have been introduced on plants from Madeira or the Cape Verde Islands by Bermuda Governor John H. Lefroy in the late 1870s (Frith, 1891: 16). By 1879, *Rumina* was abundant in Hamilton (Aldrich, 1889: 9, cited it as "so common it threatens to become injurious to the crops there"), and a few years later Hastings (1892: 334) described it as "literally eating up the island." By the 1950s it was common throughout the larger islands of Bermuda and considered a minor crop pest. Efforts were made by the Bermuda Department of Agriculture to biologically control crop pests including *Rumina decollata* using several species of predatory snails (Bennett & Hughes, 1959). Although original reports were promising (Simmonds & Hughes, 1963), later Bermuda Department of Agriculture surveys found little or no evidence of control (Monkman, 1982a). Fisher *et al.* (1980) showed that this omnivorous species itself is a predator of half-grown Brown Garden Snails in California ("*Helix*" *aspersa* Müller, 1774; recently placed in genus *Cantareus* by Giusti *et al.*, 1995: 491). *Rumina decollata* is still advocated as a control agent in California's citrus industry (UC-IPM, 1999). Its impact on Bermuda's native snail population is unknown.

Subulina octona (Bruguière, 1789)
(Map 22, Fig. 21)

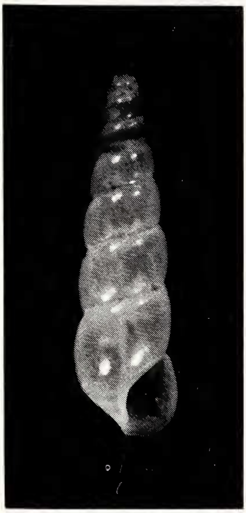


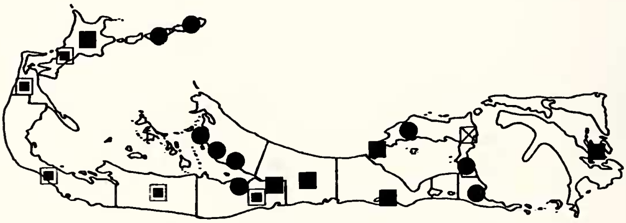
Figure 21. *Subulina octona.* - FMNH 224890, Southampton Parish, Bermuda; height = 13.3 mm.

Bulimus octonus Bruguière, 1789: 325 (Antilles).

? "*Achatina aetona* [*sic*] "Chemnitz", - Prime, 1853: 76;
Stenogyra octona, - Bland, 1881: 256; Aldrich, 1889: 9; Heilprin, 1889: 183; Bland, 1895: 271;
Subulina octona, - Pilsbry, 1900: 497, pl. 62, fig. 4; Verrill, 1902: 731, 732, fig. 77; Vanatta, 1911: 665-667; Peile, 1926: 90.

Bermuda Material Studied: BAMZ 1998- 166-006, 1998- 166- 011, 1998- 166- 019, 1998- 166-020, 1998- 166- 023, 1998- 166- 028, 1998- 166-037, 1998- 166- 061, 1998- 166- 071, 1998- 166-072, 1998- 166- 073, 1998- 166- 078, 1998- 166-090, 1998- 166- 103, 1998- 166- 112, 1998- 166-125; DMNH 210242, 210247, 210257, 210267, 210283, 210285, 210286, 210297, 210298, 210305, 210309, 210311, 210326; FMNH 104119, 224770, 224771, 224783, 224803, 224804, 224827, 224843, 224852, 224854, 224860, 224860, 224862, 224865, 224874, 224890, 224901, 224908, 227010, 227011, 227020, 227026.

Note: *Accidentally Introduced* - *Subulina octona* often is listed as a native of Latin America (Robinson, 1999), but other species of this genus are native to Africa. *Subulina octona* is now widely distributed in tropical areas, including southern Florida and the Bahamas (e.g., Deisler & Abbott, 1984). It was first recorded in Bermuda by Bland in 1881 and is now found throughout the larger islands of Bermuda under boards, garbage and stones.



Map 22. *Subulina octona.*

STREPTAXOIDEA

STREPTAXIDAE

Gonaxis kibweziensis (E. A. Smith, 1894)

(Fig. 22)

Streptaxis Kibweziensis E. A. Smith, 1894: 165, 166, fig. 1 (Kenya).

Gonaxis (*Streptaxis*) *kibweziensis*, - Simmonds & Hughes, 1963: 222;
Gonaxis kibweziensis, - Monkman, 1982a: 1; Cock, 1985: 138;
Eustreptaxis kibweziensis, - Richardson, 1988: 198.

Bermuda Material Studied: None.

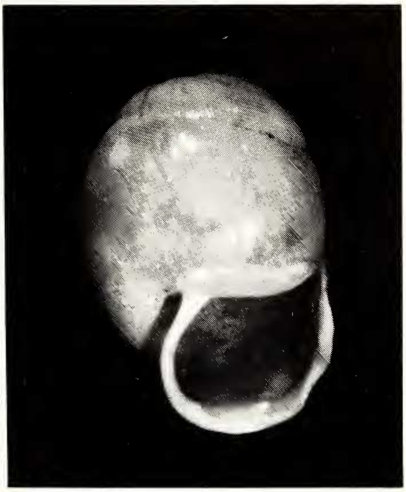


Figure 22. *Gonaxis kibweziensis*. - BPBM 217478, Marianas Islands; height = 19.8 mm.

Note: *Intentionally Introduced* - This predatory snail was brought to Hawaii in 1952 from Diana Beach, Kenya by Hawaii's Department of Agriculture (Krauss, 1964) in attempts at controlling populations of the introduced Giant African Snail, *Achatina fulica* Bowdich, 1822. In 1959, about one hundred *Gonaxis kibweziensis* specimens were sent from Hawaii via the West Indian Station CIBC (Commonwealth Institute of Biological Control) to Bermuda's Department of Agriculture to be used to control *Otala lactea* and *Rumina decollata*. In 1960, these snails were released at four sites (Simmonds & Hughes, 1963). Subsequent monitoring of these sites by Bermuda's Department of Agriculture has failed to recover individuals of this species (Monkman, 1982a), as has this survey.

***Gonaxis quadrilateralis* (Preston, 1910)**

(Map 23, Fig. 23)

***Ennea quadrilateralis* Preston, 1910: 527, pl. 7, fig. 2 (British East Africa [Kenya]).**

***Gonaxis quadrilateralis*, - Hughes, post 1968: 1; Monkman, 1982a: 1; Monkman 1982b: 71; Cock 1985: 138;**

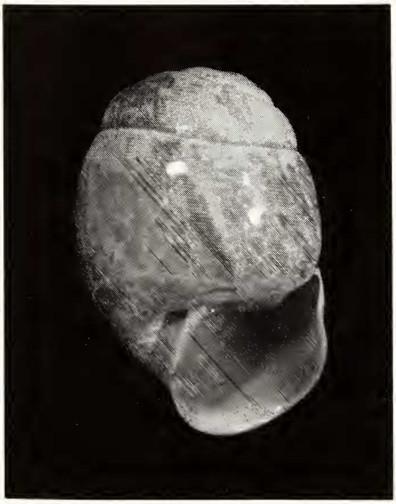


Figure 23. *Gonaxis quadrilateralis*. – Bermuda Department of Agriculture, now BAMZ; Bermuda; height = 25.0 mm.

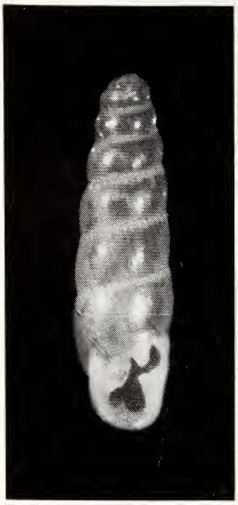
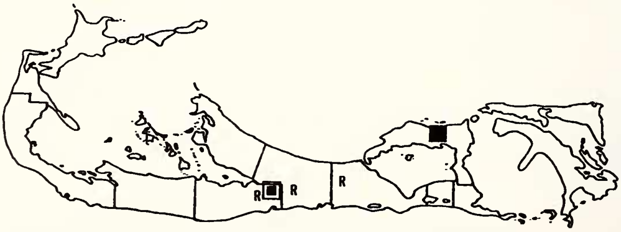


Figure 24. *Gulella bicolor*. – ANSP 48654, ex Heilprin Expedition 1888, Bermuda; height = 6.7 mm.

Eustreptaxis quadrilateralis, – Richardson, 1988: 202.

Bermuda Material Studied: BAMZ 1995-127-012, 1998-166-014, 1998-166-088; DMNH 210276; FMNH 224785, 227036, 227037, 227038.

Note: *Intentionally Introduced* - Like the previous species, *Gonaxis quadrilateralis* was introduced to Bermuda from Hawaii by the Bermuda Department of Agriculture. G. *quadrilateralis* was collected from Kwale, Kenya, and brought to Hawaii in 1957 in attempts to control *Achatina fulica* (see Krauss, 1964). In 1968 and again in 1972, G. *quadrilateralis* specimens sent from Hawaii were released at eight sites on



Map 23. *Gonaxis quadrilateralis*.

Bermuda in continuing efforts at controlling *Rumina decollata* and *Otala lactea*. [Cock (1985: 138) cited 260 specimens obtained from Hawaii in 1968 and 1972]. Since that time, *G. quadrilateralis* individuals have been collected at several of the original release sites (Monkman, 1982a). This study records the first spread of *G. quadrilateralis* beyond the original release sites.

Gulella bicolor (Hutton, 1834)
(Fig. 24)

Pupa bicolor Hutton, 1834: 86, 93 (India).

Ennea bicolor, - Pilsbry, 1900: 499; Verrill, 1902: 732;
Huttonella bicolor, - Peile, 1926: 90;
Gulella bicolor, - Naggs, 1989: 165-168 (discussion of generic placement).

Bermuda Material Studied: ANSP 48654.

Note: *Accidentally Introduced* - Native to the Indian subcontinent (Naggs, 1989), this species has been introduced around the world in the tropics and subtropics including the southeastern United States (Dundee, 1970; Auffenberg & Stange, 1986) and Caribbean (van der Schalie, 1948). Records of this species on Bermuda are based on a single shell (ANSP 48654), collected by the Heilprin party in 1888 and first mentioned in publication by Pilsbry in 1900. The species was not found in the present survey and may not be established on Bermuda (note, however, that its burrowing habits make it difficult to find).

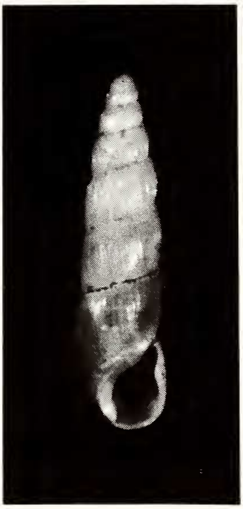
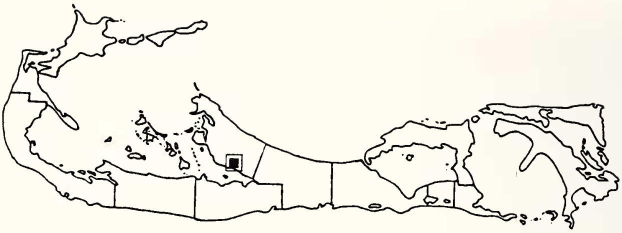


Figure 25. *Streptostele musaecola*. - FMNH 227045, Paget Parish, Bermuda; height = 6.0 mm.

Streptostele musaecola (Morelet, 1860) NEW RECORD
(Map 24, Fig. 25)

Achatina musaecola Morelet, 1860: 190 (Guinea).

Bermuda Material Studied: FMNH 227045.



Map 24. *Streptostele musaecola.*

Note: *Accidentally introduced* - Originally described from West Africa, this species was accidentally introduced to several islands in the Pacific (Solem, 1989). A specimen from the city of Hamilton (FMNH 227045), collected in 1992, is the first record of this species from the western Atlantic region.

RHYTIDOIDEA

RHYTIDIDAE

Natalina cafra (Férussac, 1821)

(Map 25, Fig. 26)

Helix (Helicophanta) cafra Férussac, 1821: 25 [or p. 29, depending on issue] (South Africa).

Natalina cafra, - Simmonds & Hughes, 1963: 221;
Natalina caffra [*sic*] - Hughes, 1962; Hughes, 1963; Hughes, post 1968: 1; Monkman, 1982a: 1; Cock, 1985: 138.

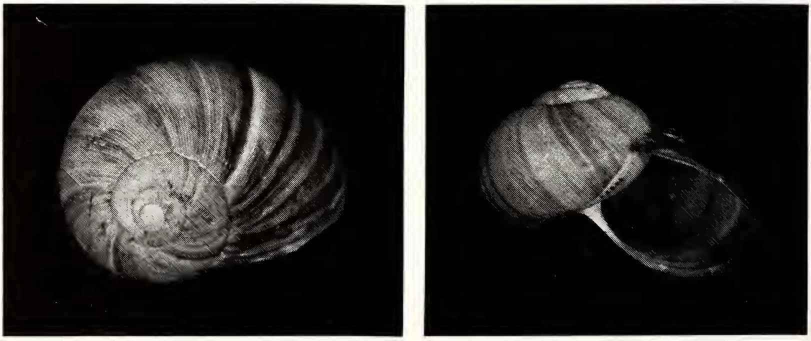
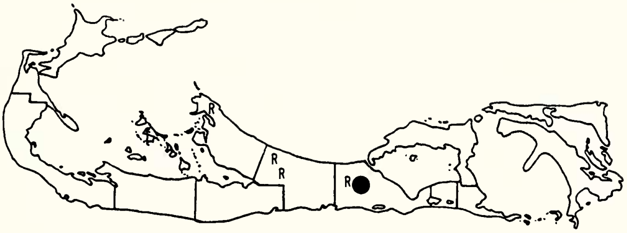


Figure 26. *Natalina cafra.* - left: FMNH 199492, Natal, South Africa, diameter = 65.4 mm; right: FMNH 76882, South Africa, diameter = 70.1 mm.



Map 25. *Natalina cafra.*

Bermuda Material Studied: None.

Note: *Intentionally Introduced* - About sixty individuals of this South African species were released in Smith's Parish on Bermuda beginning in 1960, as part of continuing efforts to control populations of *Otala* and *Rumina* (Simmonds & Hughes, 1963; Hughes, post 1968). Shipments were discontinued in 1962 when surveys recorded only one live individual at Bermuda's Arboretum, one of the original release sites (Hughes, unpubl. reports for 1962, 1963). Since that time no additional individuals have been recorded (Monkman, 1982a).

ARIONOIDEA

PUNCTIDAE

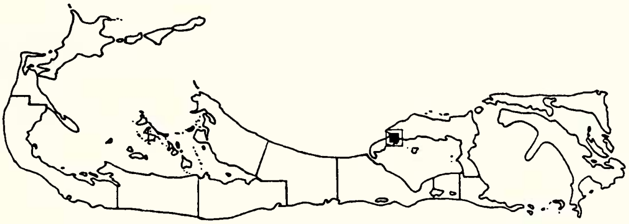
Punctum bristoli (Gulick, 1904) NEW EXTANT RECORD

(Map 26, Fig. 27)

Zonitoides bristoli Gulick, 1904: 421, pl. 36, fig. 13 (Bermuda, fossil).

Zonitoides bristoli, – Verrill, 1906: 168, fig. 51 (after Gulick; fossil); Vanatta, 1912: 12 (fossil); Hughes, post 1969: 1 (fossil); Gould, 1970b: 491, fig. 1f (fossil);

Punctum bristoli, – Vanatta, 1924: 7 (fossil);



Map 26. *Punctum bristoli.*

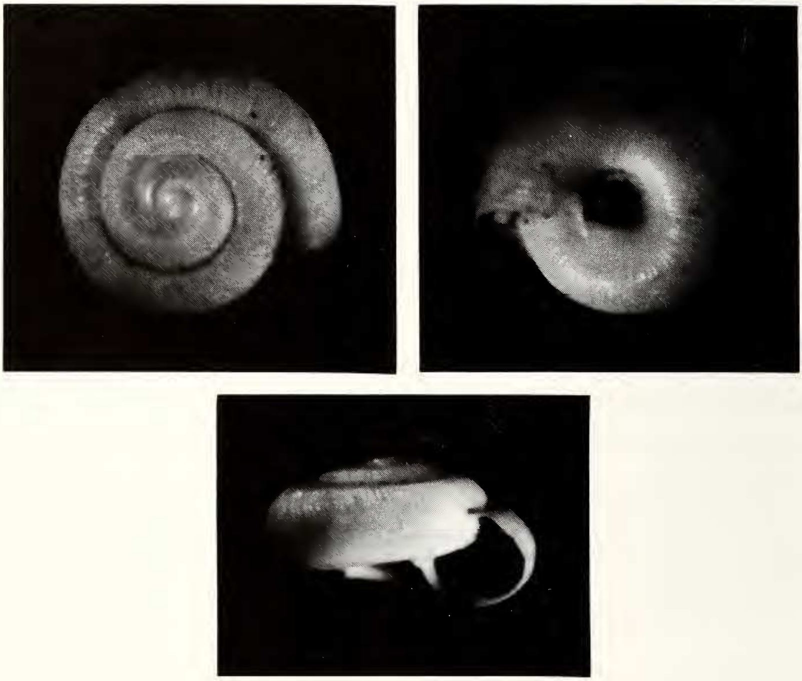


Figure 27. *Punctum bristoli.* – BAMZ 1995-132-013, Bermuda, diameter = 1.28 mm.

Punctum (?) bristoli, – Peile, 1926: 89 (fossil).

Bermuda Material Studied: ANSP 85572 (fossil); BAMZ 1995-132-013 (fossil); FMNH 227042; MCZ Gould Station 1 (fossil), Gould Station 4 (fossil), Gould Station 21 (fossil), Gould Station 21b (fossil), Gould Station 41 east (fossil), Gould Station 48 (fossil), Gould Station 63 (fossil).

Note: *Endemic* - This study records the first Recent specimens of this small-shelled species (FMNH 227042). Pleistocene specimens are commonly found in siftings from Bermuda's fossil deposits. The lack of Recent records of this species is probably due to insufficient efforts to sort such micromollusks from soil and leaf litter samples.

HELICODISCIDAE

Helicodiscus singleyanus (Pilsbry, 1889)

(Map 27, Fig. 28)

---, Pilsbry, 1888: pl. 17, figs., M, M, M;
Zonites singleyanus Pilsbry, 1889: 84 (Texas).

Zonitoides singleyanus, - Peile, 1926: 89.

Bermuda Material Studied: FMNH 227047.

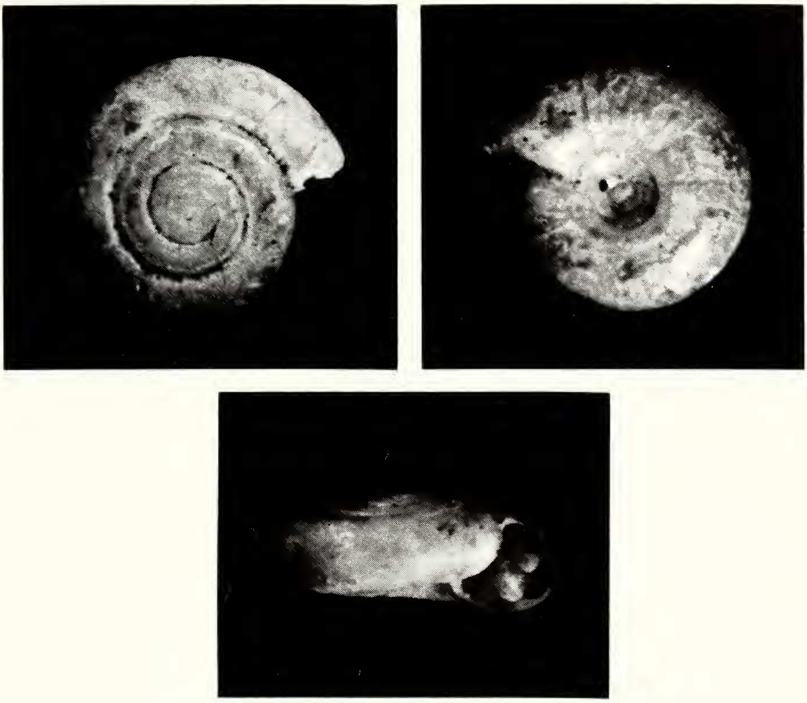
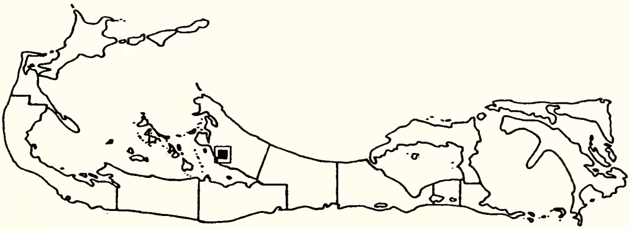


Figure 28. *Helicodiscus singleyanus*. - FMNH 227047, Paget Parish, Bermuda; diameter = 2.0 mm.



Map 27. *Helicodiscus singleyanus*.

Note: *Accidentally Introduced* – Native to eastern and central North America (Hubricht, 1985), this species has been introduced throughout Europe and into North Africa (Seddon & Holyoak, 1993). It is subterranean and can be sifted from loose soil around the roots of grasses and herbaceous plants along roadsides and other open areas. This elusive species was previously recorded from Bermuda only by Peile (1926). The present survey found one specimen in the city of Hamilton (FMNH 227047). Like other soil-inhabiting species, *Helicodiscus singleyanus* is probably much more common than the sparse records indicate.

SUCCINEOIDEA

SUCCINEIDAE

Succinea bermudensis Pfeiffer, 1857

(Map 28, Fig. 29)

Succinea bermudensis Pfeiffer, 1857: 110 (Bermuda).

Succinea ---, Redfield, 1853: 17; Tristram, 1861: 405;
Succinea Bermudensis Prime, 1853: 55 [*nomen nudum*];
Succinea Bermudensis Jones, 1859: 107 [*nomen nudum*; based on Prime's list, but erroneously indicated as "n.s."];

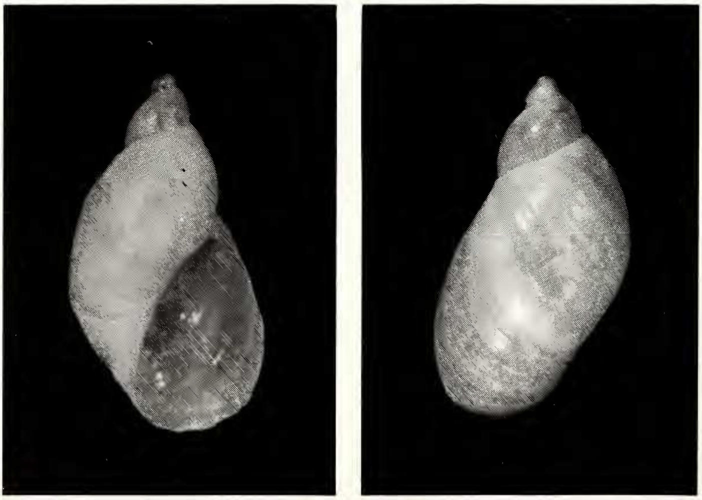


Figure 29. *Succinea bermudensis*. – BAMZ 1995-132-006, Bermuda; left, height = 12.6, right, height = 12.0 mm.

Succinea bermudensis, - Pfeiffer, 1859: 817; Bland, 1861: table 2, p. 351; Rein, 1867: 76; Jones, 1876: 139; Mörch, 1878: 3; Kobelt, 1880: 286; Bland, 1881: 256 E. A. Smith, 1884: 277; Heilprin, 1889: 182; Bland, 1895: 270; Gulick, 1904: 421; Davis, 1904: 125; Verrill, 1906: 171; Vanatta, 1911: 665-668; Peile, 1926: 91; Tomlin, 1932: 98-100, figs. C, D; Hughes, post 1968: 1; Gould, 1970b: 500 (fossil);

Succinea fulgens Lea, - Bland, 1861: table 2, p. 351; Jones, 1876: 139; Kobelt, 1880: 286; Bland, 1881: 256; Heilprin, 1889: 182; Bland, 1895: 270 [*non Succinea fulgens* Lea, 1841];

Succinea margarita Pfeiffer, - Bland, 1861: 351; Jones, 1876: 139; Kobelt, 1880: 286; Bland, 1881: 256; Heilprin, 1889: 182; Bland, 1895: 270, table 2 [*non Succinea margarita* Pfeiffer, 1853];

Succinea texasiana Pfeiffer, 1848, - Jones, 1864: 9 [*non Succinea texasiana* Pfeiffer, 1848];

Sucinea [*sic*] *putris*, - Bartram, 1878: 108 [*non Helix putris* Linné, 1758: 774];

Succinea barbadensis Guilding, 1828, - Pilsbry, 1900: 502; Verrill, 1902: 729, 732, 733, figs. 80a, b; Vanatta, 1923:33; [? *non Succinea barbadensis* Guilding, 1828];

Succinea (*Tapada*) *bermudensis*, - Clessin in Pfeiffer, 1879: 416;

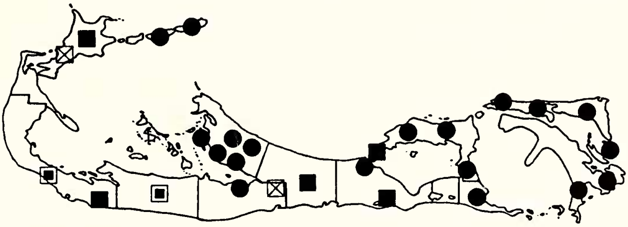
Succinea gabrieli Tomlin, 1932: 99-100, figs, A, B, pl. 9A (Bermuda);

Succinea barbadensis "Gould", - Kutchka, 1934: 295;

Succinia [*sic*] *bermudensis*, - Hughes, post 1969: 1.

Bermuda Material Studied: BAMZ 1998-166-052, 1998-166-057, 1998-166-113; DMNH 210268, 210290, 210319; FMNH 3628, 13483, 13496, 13509, 13511, 13516, 13519, 13526, 13549, 13569, 13572, 13575, 13578, 13681, 16462 (fossil), 16463, 29800, 30191, 30216, 41016, 49546, 104491, 104612, 141807, 224780, 224798, 224828, 224841, 224891, 224902, 224909, 227012.

Note: *Endemic* - Pilsbry (1900: 492) considered this species to be conspecific with *Succinea barbadensis* of Barbados. However, identifications based on shell



Map 28. *Succinea bermudensis*.

characteristics in species with reduced shells, such as those of the succineids, are notoriously unreliable. Comparisons of anatomical features are necessary to determine if *S. barbadensis* and *S. bermudensis* are indeed conspecific. Pending this, we have considered the two nominal species distinct and *Succinea bermudensis* endemic to Bermuda. *Succinea gabrieli* Tomlin, 1932, introduced based on slight differences in shell morphology and radular tooth counts, is most likely conspecific with *S. bermudensis*. *Succinea bermudensis* is common on grasses and on the bark of trees, often in open areas, and is also commonly found as a Pleistocene fossil.

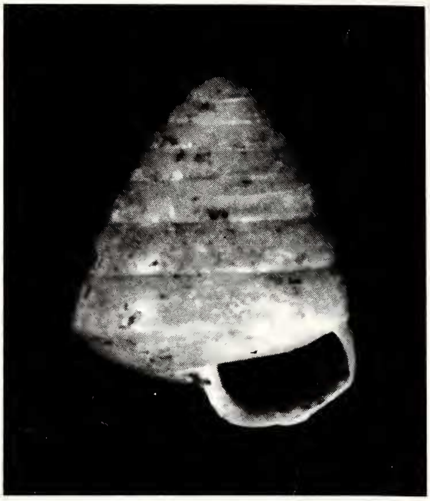
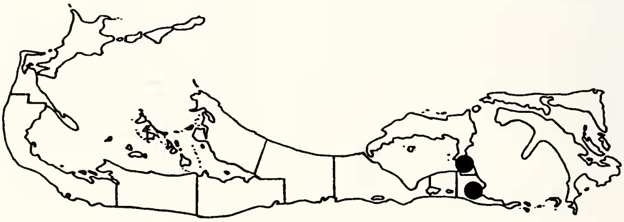


Figure 30. "*Euconulus*" *turbinatus*. – ANSP 91153, Hamilton Parish, Bermuda; height = 3.65 mm.

LIMACOIDEA
HELICARIONIDAE
"Euconulus" turbinatus Gulick, 1904
(Map 29, Fig. 30)

Euconulus turbinatus Gulick, 1904: 420, pl. 36, figs. 8-10 (Bermuda, fossil).

Euconulus turbinatus, – Verrill, 1906: 168, figs. 55a, b (types; "not known to be living"); Gould, 1970b: 491;



Map 29. "*Euconulus*" *turbinatus*.

Kaliella turbinatus, – Vanatta, 1911: 665;
Kaliella turbinata, – Pilsbry & Vanatta, 1909: 64; Vanatta, 1911: 666-667; Peile, 1926: 89.

Bermuda Material Studied: ANSP 91153; FMNH 43379; MCZ Gould Station 1 (fossil), Gould Station 41 east (fossil).

Note: *Endemic* - Described from fossils on Bermuda and tentatively placed in the genus *Euconulus* (Gulick, 1904), this species was later found living around Church Cave (Pilsbry & Vanatta, 1909). Using shell and radular characteristics, Godwin Austen (in Pilsbry & Vanatta, 1909) determined this species to belong to the Asian genus *Kaliella*, leading Pilsbry & Vanatta to consider Gulick's specimens subfossil and the species a very early introduction. Studies of the Pleistocene fossils of Bermuda confirm this species' presence in Pleistocene deposits and its endemic status (Gould, 1971b). Anatomical material is needed to establish its generic position and relationships with other helicarionids.

AGRIOLIMACIDAE

Deroceras laeve (Müller, 1774)

(Map 30, Fig. 31)

Limax laevis Müller, 1774: 1-2 (Europe).

Agriolimax campestris (Binney, 1842), – Cockerell in Bland, 1895: 271 [described as *Limax campestris* Binney, 1842];

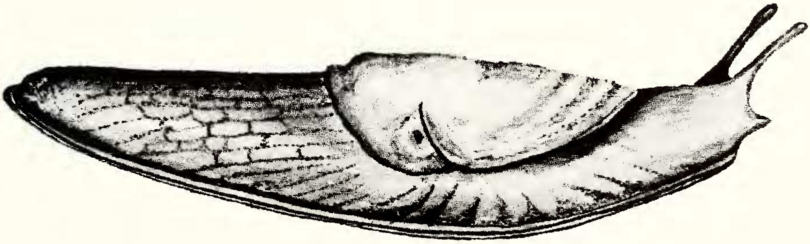
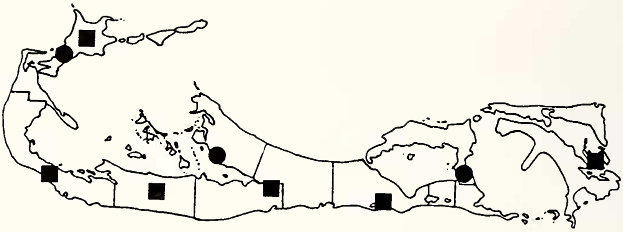


Figure 31. *Deroceras laeve*. – FMNH 224864, St. Georges Parish; lateral view; body length = 14 mm.

Agriolimax laevis, – Pilsbry, 1900: 501; Verrill, 1902: 734; Vanatta, 1911: 665-668;
Malino laevis, – Peile, 1926: 90.



Map 30. *Deroceras laeve.*

Bermuda Material Studied: BAMZ 1998-166-092, 1998-166-094, 1998-166-098, 1998-166-102, 1998-166-107, 1998-166-109, 1998-166-123; DMNH 210249, 210254, 210256, 210263, 210273, 210335, 210336; FMNH 224774, 224816, 224864, 224872, 224875, 224893, 227055, 227056.

Note: *Accidentally Introduced* - A very widely distributed slug, *Deroceras laeve* is found throughout much of the Northern Hemisphere. Found in gardens or along foundations it is most commonly seen in rainy weather or at night. *Deroceras laeve* was first collected in Bermuda by the British 'Challenger' expedition in 1873.

LIMACIDAE

Limacus flavus (Linné, 1758)

(Map 31, Fig. 32)

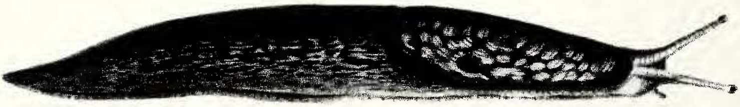
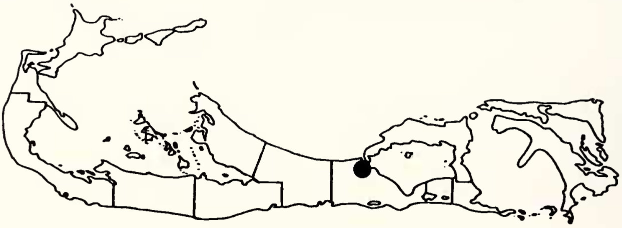


Figure 32. *Limacus flavus.* – after Moquin-Tandon, 1855: pl. 3, fig. 3; body length = 75 to 100 mm.



Map 31. *Limacus flavus.*

Limax flavus Linné, 1758: 652 (Europe).

Limax flavus, - Pilsbry, 1900: 501; Verrill, 1902: 734, fig. 83; Peile, 1926: 90; Hughes 1968: 1;
Limacus flavus (Linné, 1758), - Falkner in Fechter & Falkner, 1990: 190 [European distribution and placement in *Limacus*].

Bermuda Material Studied: FMNH 198685.

Note: *Accidentally Introduced* - Found in urban areas around the world, this native of Europe was first collected on Bermuda by Verrill in 1898. Incomplete locality data on most Bermudan specimens obscures the distribution of this species on Bermuda. This very large slug can be found at night, especially on stone fences and in gardens. Dissection of FMNH 198685 confirmed the specific identity of this slug, which is often confused with *Limacus maculatus* (Kaleniczenko, 1851).

MILACIDAE

Milax gagates (Draparnaud, 1801)
(Map 32, Fig. 33)

Limax gagates Draparnaud, 1801: 100 (France).

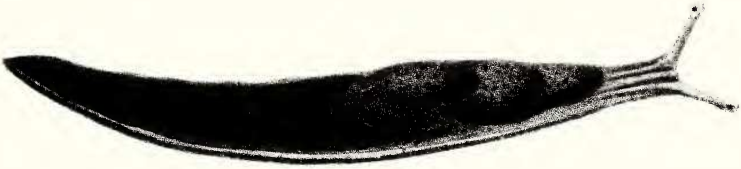
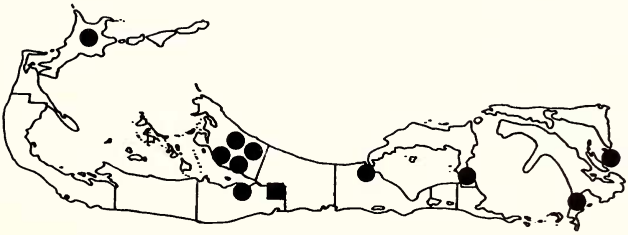


Figure 33. *Milax gagates*. - after Moquin-Tandon, 1855: pl. 2, fig. 1; body length = 50 to 60 mm.



Map 32. *Milax gagates*.

Limax gagates, – E. A. Smith, 1884: 276;
Amalia gagates, – Bland, 1895: 271; Pilsbry, 1900: 501; Verrill, 1902: 734;
Milax sowerbyi (Férussac, 1823), var., – Vanatta, 1911: 665-668 [*non Limax sowerbii* [*sic*] Férussac, 1823];
Milax sowerbyi, – Peile, 1926: 90;
Milax gagates, – Vanatta, 1911: 665-667; Peile, 1926: 90; Hughes, 1968: 1.

Bermuda Material Studied: FMNH 224759.

Note: *Accidentally Introduced* - *Milax gagates* was first collected on Bermuda by the British 'Challenger' expedition in 1873 (E. A. Smith, 1884). A native of Europe, it burrows in soil and feeds on plant roots. Introduced around the world in potted plants (Karlin & Naegele, 1966), it has become so ubiquitous in greenhouses it has earned the common name "The Greenhouse Slug" (Pilsbry, 1948). It is placed in genus *Tandonia* by some authors.

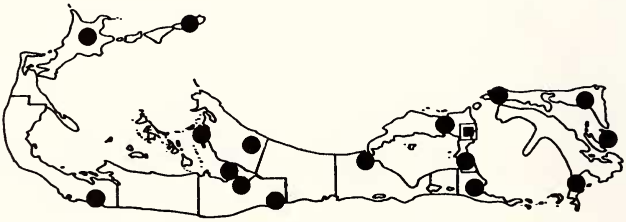
ZONITIDAE

Hawaiia minuscula (Binney, 1841)

(Map 33, Fig. 34)

Helix minuscula Binney, 1841: 435-436 pl. 22, fig. 4 (Ohio).

Zonitoides minusculus, – Pilsbry, 1900: 501, pl.62, fig.17; Verrill, 1902: 729, fig. 71; Gulick, 1904: 421 (Recent and "fossil"); Verrill, 1906: 168, figs. 52a, b (after Binney); Peile, 1926: 89; Hughes, post 1969: 1; Gould, 1970b: 491;
Zonitoides minuscula, – Vanatta, 1911: 665-668; Vanatta, 1923: 33; Vanatta, 1924: 7;
Hawaiia minuscula, – Riedel, 1980: 28-29.



Map 33. *Hawaiia minuscula.*

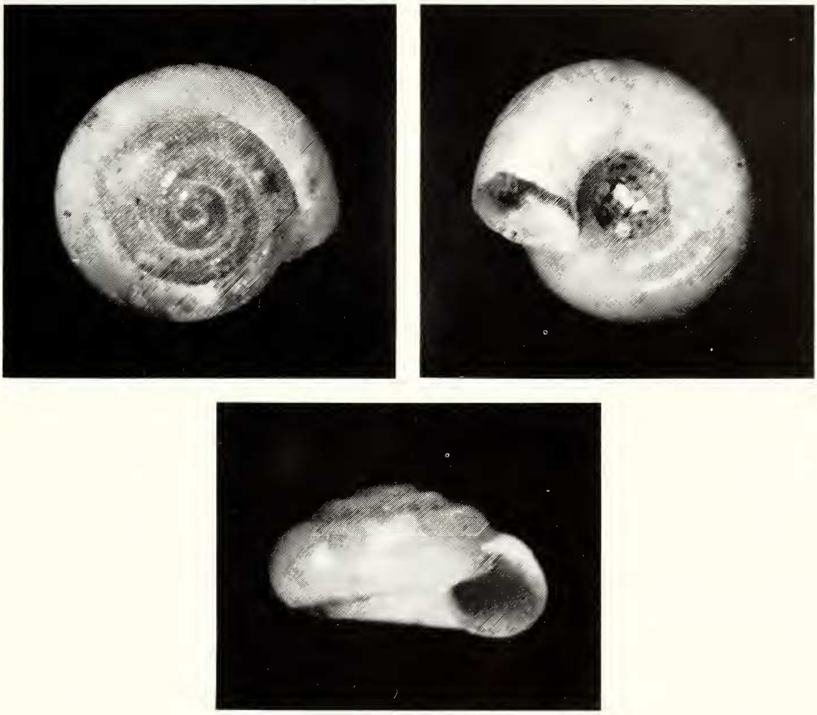


Figure 34. *Hawaiia minuscula*. - FMNH 227046, Hamilton Parish, Bermuda; diameter = 2.1 mm.

Bermuda Material Studied: BAMZ 1995-132-014; FMNH 30204, 30205, 41019, 227035, 227046.

Note: *Accidentally Introduced* - Commerce has transported this native of North America around the world, as attested by the generic name, which is based on specimens mistakenly thought native to Hawaii. *Hawaiia minuscula* is usually found on bare ground in yards, fields and other open areas. Gould (1970b) questioned the fossil record by Gulick (1904); Gulick (1904: 421) himself expressed surprise at this singular occurrence and absence at all other sites studied by him. The later references to Bermuda fossils of this species by Verrill (1906) and Hughes (post 1969) are based on Gulick's single record. Gulick's collecting site was probably contaminated with Recent material.

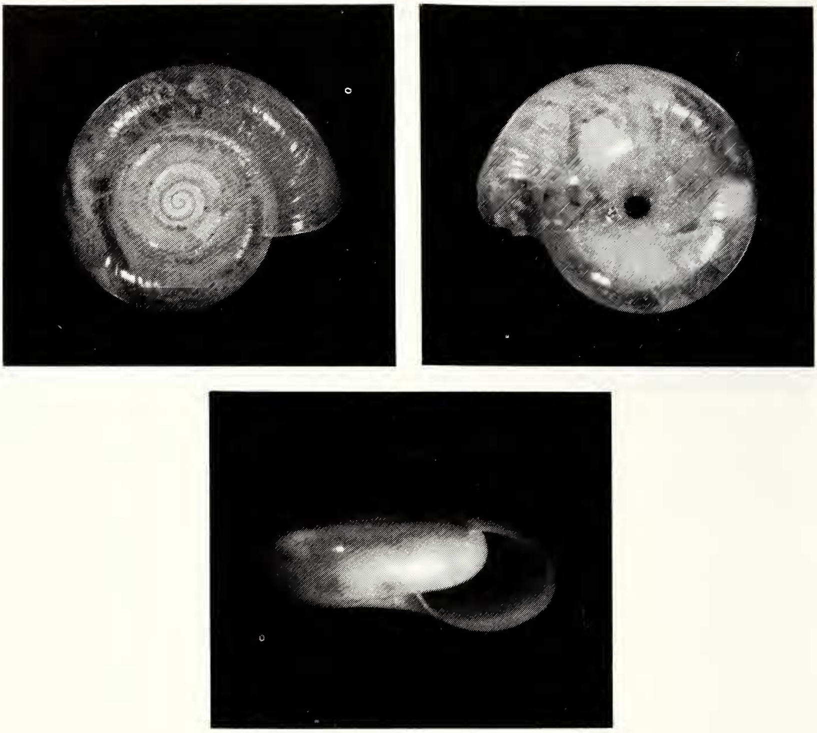
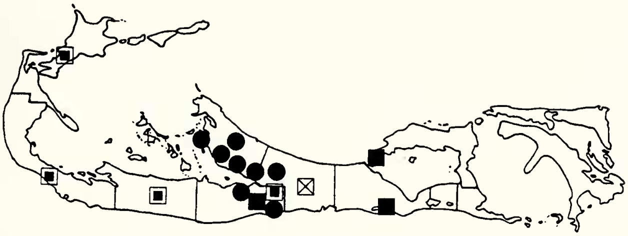


Figure 35. *Oxychilus draparnaudi.* - FMNH 13547, Paget's Parish, Bermuda; diameter = 10.9 mm.

Oxychilus draparnaudi (Beck, 1837)
(Map 34, Fig. 35)

Helix (Helicella) Draparnaldi [*sic*] Beck, 1837: 6 [new name for *Helix nitida* Draparnaud, 1805, *non* Müller, 1774]; *non Helix draparnaldi* Cuvier, 1816, *nec Helix draparnaudi* Sheppard, 1823 [see Manganelli & Giusti, 1997: 149-150].

Helix cellaria Müller, 1774 - Prime, 1853: 77 [*non Helix cellaria* Müller, 1774];
Hyalina lucida (Draparnaud, 1801), - Verrill, 1902: 733, fig. 81a, b; Davis, 1904: 126; [described as *Helix lucida* Draparnaud, 1801; *non Helix lucida* Pulteney, 1799];
Vitrea cellaria Müller, 1774, - Davis, 1904: 126 [*non Vitrea cellaria* Müller, 1774];



Map 34. *Oxychilus draparnaudi.*

Vitrea lucida (Draparnaud, 1801), - Bryant, 1905: 131; Vanatta, 1911: 666-667;

Helicella draparnaldi [*sic*], - Peile, 1926: 89;

Helicella draparnaldi, - Ellis, 1951: 126 [petition to place on Official List of Names];

Helicella draparnaudi, - ICZN, 1955: 81, 87, 99 [placement of the emended specific name on the Official List of Specific Names in Zoology; with erroneous "original" generic combination];

Oxychilus draparnaudi, - Manganelli & Giusti, 1997: 148 ff. [proposed conservation of specific name *Oxychilus draparnaudi* (Beck, 1837), based on *Helix draparnaldi*].

Bermuda Material Studied: BAMZ 1998-166-038, 1998-166-041, 1998-166-117, 1998-166-118; DMNH 210260, 210261, 210288; FMNH 13503, 13558, 13577, 13680, 13684, 224757, 224767, 224799, 224823, 224848, 224886, 224898, 224906, 227006, 227007.

Note: *Accidentally Introduced* - This species was first collected on Bermuda in 1852 and reported as the similar species "*Helix*" *cellaria* by Prime (1853). Museum records (all prior to 1950) and localized reports (Verrill, 1902; Vanatta, 1911) show this species limited to the vicinity of the city of Hamilton, the likely point of its introduction. The current survey finds O. *draparnaudi* common throughout the western two thirds of Bermuda. A native of Europe, western Asia and northern Africa, this species has been introduced to cities throughout North America. *Oxychilus draparnaudi* is often found in gardens and vacant lots.

***Poecilozonites bermudensis* (Pfeiffer, 1845)**
(Map 35, Fig. 36)

Helix Bermudensis **Pfeiffer, 1845: 67 (Bermuda).**

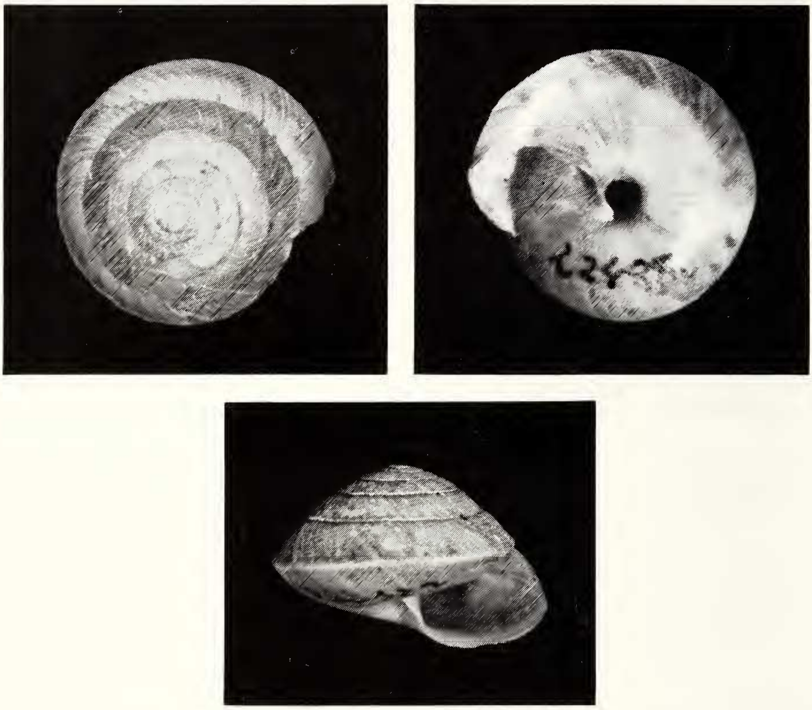


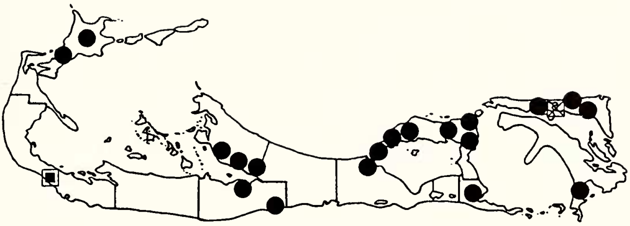
Figure 36. *Poecilozonites bermudensis.* – FMNH 224886, Southampton Parish, Bermuda; diameter = 17.1 mm (apical view); diameter = 15.4 mm (basal and apertural views).

? *Helix ochroleuca*, – Pfeiffer, 1847: 80-81; Reeve, 1854: *Helix* pl. 177, no. 1212; Bland, 1861: 351;

Helix (*Trochomorpha*) *bermudensis*, – Albers, 1850: 116;

? *Helix* (*Trochomorpha*) *ochroleuca* Férussac, – Albers, 1850: 116 [non *Helix* (*Helicostyla*) *ochroleuca* Férussac, 1821: 46 ("Les Grandes Indes?," subsequently changed to "Habite l'île Bermude (Menke)" by Férussac [in Férussac & Deshayes], 1819-1851: 183); *H. ochroleuca* Férussac was later interpreted as a senior synonym of *Pachystyla rufozonata* H. Adams, from Mauritius, by Pilsbry 1900: 499];

Helix bermudensis, – Prime, 1853: 55; Reeve, 1851: *Helix* pl. 57, no. 275; Jones, 1859: 106; Bland, 1861: 351; Tristram, 1861: 405; Rein, 1867: 77; Bland & Binney, 1873: 221; Mörch, 1878: 3; Bartram, 1878: 108; Kobelt, 1880: 258; E. A. Smith, 1884: 277; Martens, 1889: 201; Lane, 1891: 1;



Map 35. *Poecilozonites bermudensis.*

? *Nanina (Trochomorpha) ochroleuca,* – Martens in Albers, 1860: 60-61 (expressing doubt about the presence of this species on Bermuda because it was not listed by Jones in 1859);

Helix (Caracolus) bermudensis, – Martens in Albers, 1860: 156;

Hyalina bermudensis, – Bland, 1875: 77; Jones, 1876: 138; Bland, 1881: 256;

Hyalina ochroleuca, – Jones, 1876: 138;

Zonites (?) *bermudensis,* – Binney, 1876: 183; Binney, 1884: 86, 87;

? *Hyalina ochrolenca* [*sic*], – Jones, 1876: 138;

Hyalina [*sic*] *bermudensis,* – Jones, 1876: 138; Bartram, 1878: 108;

Hyalinia ? Bermudensis Clessin in Pfeiffer, 1879: 69;

Hyalinia bermudensis, – Kobelt, 1880: 286;

? *Carocolla ochroleuca,* – Kobelt, 1880: 286;

Zonites bermudensis, – E. A. Smith, 1884: 31;

Poecilozonites bermudensis, – O. Boettger, 1884: 139 [introduction of genus-group name *Poecilozonites*, 2 species originally included]; Pilsbry, 1888: 289-290, pl. 17, fig. E, C; Heilprin, 1889: 182; Pilsbry, 1889: pl. 17, figs. N, O; Pilsbry, 1889: 85; Bland, 1895: 270; Pilsbry, 1900: 499; Verrill, 1902: 782; Gulick, 1904: 418; Verrill, 1906: 159 ff.; Vanatta, 1911: 665-668; Vanatta, 1923: 33; Vanatta, 1924: 7; Peile, 1926: 89; Kutchka, 1934: 296; Gould, 1969: 507, pl. 3, figs. 6-7 (Recent), pl. 4, fig. 6 (fossil), fig. 7 (Recent); Gould, 1970b: 502 ff. (fossil); Gould, 1971a: 88 (fossil); Abbott, 1989: 126, fig; Gould, 1991: 12;

Helix (group *Patula,* section *Trochomorpha,* subsection *Poecilozonites) bermudensis,* – Tryon, 1887: 95, 96, pl. 19 figs. 7-10 [*H. bermudensis* indicated as type species of *Poecilozonites* Sandberger [*sic*, error for O. Boettger], 1884];

Bermudia bermudensis, – Ancey, 1887: 53 [introduction of genus-group name *Bermudia, with H. bermudensis* as type species by monotypy];

Juno bermudensis, – Mazÿck, 1889: 210-211 [introduction of genus-group name *Juno*, with *H. bermudensis* as type species by original designation];

Poecilozonites bermudensis bermudensis, - Gould, 1966: 1135; Gould, 1968: 81 ff., pl. 10, fig. 6 (fossil), fig. 7 (Recent); Hughes, post 1968: 1; Hughes, post 1969: 1; Eldredge & Gould, 1972: 99 ff.;

Poecilozonites (*Poecilozonites*) *bermudensis*, - Thiele, 1931: 595; Zilch, 1959: 263, fig. 933; Riedel, 1980: 23.

Bermuda Material Studied: BAMZ 1994-118-009, 1998-166-025, 1998-166-053 (fossil); 1998-166-055, 1998-166-060; DMNH 210287, 210304, 210327 (fossil); FMNH 3633, 8833, 8858, 13482, 13492, 13502, 13506, 13507, 13524, 13532, 13580, 16455, 16456 (fossil), 29787 (fossil), 29788 (fossil), 29799, 45243 (fossil), 45244, 45245, 45246, 71536, 82048, 93871, 100125, 100184, 103063, 106932, 115118, 127348, 127430 (fossil), 147304, 216369, 224859, 224886, 224910 (fossil), 227059.

Note: *Endemic* - The closest relatives of the genus *Poecilozonites* are the members of the southeastern United States genera *Gastrodonta* and *Ventridens* (Pilsbry, 1900). Once extremely common on Bermuda, *Poecilozonites bermudensis* specimens were collected by the bucket-full and destroyed by burning in the middle part of this century (Gould, 1969). Jones (1864: 8) referred to this species as "Quite as common as the Garden Snail (*H. aspersa*) is in England." After the introduction of several predatory snails, populations of *Poecilozonites bermudensis* rapidly declined (Gould, 1969, 1991) and recently this species was feared extinct (Gould, 1991). In 1988, this survey located fresh-dead specimens of this species (FMNH 224886) at one locale, giving hope to future efforts to protect this species.

This is the type species of *Poecilozonites* O. Boettger (1884: 139) and its two objective synonyms *Bermudia* Ancey (1887: 53), and *Juno* Mazÿck (1889: 211).

Poecilozonites circumfirmatus (Redfield, 1853)
(Map 36, Fig. 37)

Helix circumfirmata Redfield, 1853: 16, 17 (Bermuda).

Helix ptychoides Prime, 1852: 55 [*nomen nudum*]; Jones, 1859: 106 [*nomen nudum*; based on Prime's list]; Bartram, 1878: 108 [*nomen nudum*; erroneously referring to "Rein"];

Helix circumfirmata, - Shuttleworth, 1853: 123; Bland, 1861: 351; Pfeiffer, 1863: 2; Rein, 1867: 77; Bland & Binney, 1873: 221; E. A. Smith, 1884: 277; Mörch, 1878: 3; Bartram, 1878: 108; E. A. Smith, 1884: 31;

Helix circumfirmatus, - Tristram, 1861: 405;

Helix discrepans Pfeiffer, 1863: 1-2 (Bermuda); Rein, 1867: 77;

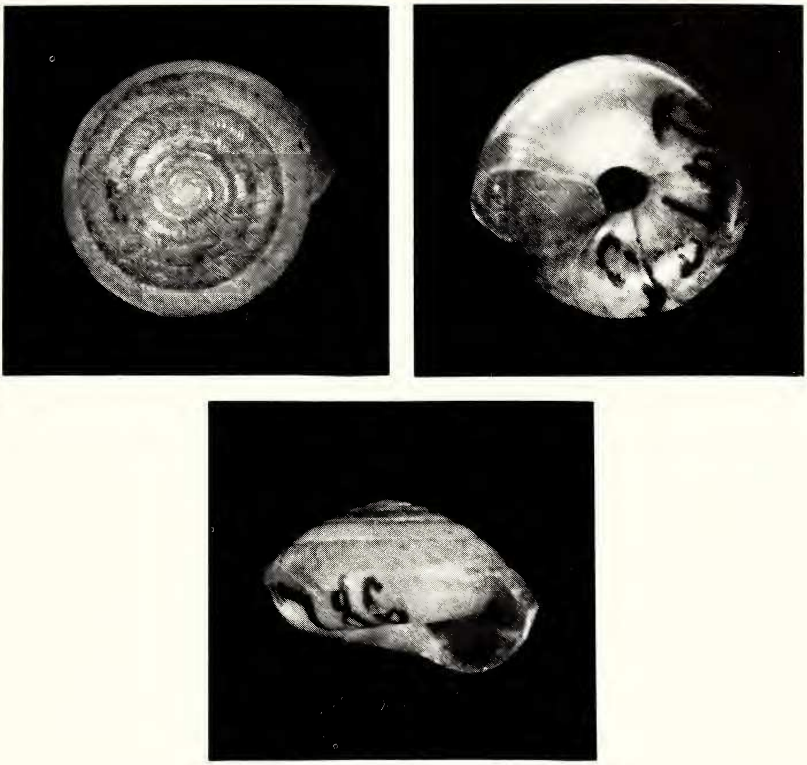
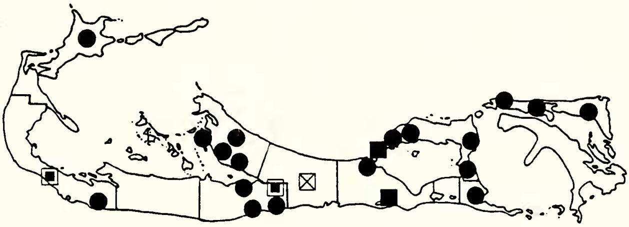


Figure 37. *Poecilozonites circumfirmatus*. - FMNH 29786, St. George's Parish, Bermuda; diameter = 8.6 mm (apical and basal views); diameter = 7.8 mm (apertural view).

Hyalina discrepans, - Pfeiffer, 1868: 216; Jones, 1876: 138; Bland, 1881: 256;
Hyalina circumfirmata, - Jones, 1876: 138; Bland, 1881: 256;
Hyalosagda discrepans, - Kobelt, 1880: 286;
Hyalosagda circumfirmata, - Kobelt, 1880: 286;
Helix (group *Sagda*, section *Hyalosagda*) *circumfirmata*, - Tryon, 1887: 9, pl. 1,



Map 36. *Poecilozonites circumfirmatus*.

fig. 30;

Helix (group *Sagda*, section *Hyalosagda) discrepans*, - Tryon, 1887: 9;

Poecilozonites circumfirmatus variety Pilsbry, 1888: 291, pl. 17, fig. 11;

Poecilozonites circumfirmatus, - Pilsbry, 1888: 291, pl. 17, figs. A, B, F; Heilprin, 1889: 182; Pilsbry, 1900: 500, pl. 62, fig. 9, 9a; Verrill, 1902: 728, figs. 67a, b; Gulick, 1904: 420; Verrill, 1906: 166, figs. 48a, b; Vanatta, 1911: 665-668; Peile, 1924: 18-19; Vanatta, 1924: 7; Gould, 1966: 1135; Hughes, post 1968: 1; Hughes, post 1969: 1; Gould, 1966: 1135; Gould, 1971a: 88 (fossil);

Helix (Hyalosagda) discrepans, - Heilprin, 1889: 182;

Poecilozonites circumfirmatus var. corneus Pilsbry, 1890a: 95;

? Hyalnia [*sic*] ---, - Lane, 1891: 3;

Poecilozonites circumfirmatas [*sic*], - Bland, 1895: 270;

Poecilozonites discrepans, - Bland, 1895: 270; Peile, 1925: 257; Peile, 1926: 89;

Poecilozonites (Gastrelasmus) circumfirmatus, - Pilsbry, 1924: 2 [introduction of genus-group name *Gastrelasmus* with *H. circumfirmata* as type species by original designation];

Poecilozonites (Gastrelasmus) circumfirmatus discrepans, - Pilsbry, 1924: 3, fig. 2, a, b;

Poecilozonites circumfirmatus var. caliban Peile, 1924: 19;

Poecilozonites circumfirmatus mut. corneus, - Pilsbry, 1924: 2, fig. 1;

Poecilozonites peilei Vanatta, 1925: 423, figs. 1, 2;

Poecilozonites circumfirmatus var. corneus, - Peile, 1925: 257; Peile, 1926:89;

Poecilozonites circumfirmatus var. caliban, - Peile, 1926: 89;

Poecilozonites circumfirmatus peilei, - Peile, 1926: 89;

Poecilozonites (Gastrelasmus) circumfirmatus, - Peile, 1926: 89; Thiele, 1931: 595; Zilch, 1959: 263, fig. 934;

Poecilozonites (Poecilozonites?) peilei, - Riedel, 1980: 23;

Poecilozonites (Gastrelasmus) circumfirmatus, - Riedel, 1980: 23.

Bermuda Material Studied: BAMZ 1994-118-008, 1998-166-012, 1998-166-032, 1998-166-056; CAS 54685; DMNH 210281, 210303, 210318; FMNH 11429, 13489, 13494, 13512, 13553, 13565, 13581, 16457, 16458, 29803 (fossil), 41763, 45247 (fossil), 45248, 45249 (fossil), 70863, 71537, 92868, 93813, 100080, 100186, 102848, 114991, 129496, 147327, 217552, 224786, 224813, 224825, 224838, 224850, 224887.

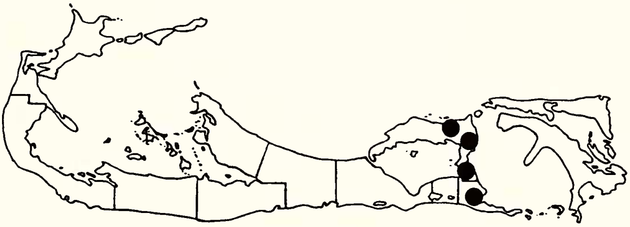
Note: *Endemic* - Once very common and widespread on the larger islands of Bermuda, this is the only member of the genus to be found alive in this latest survey. Most records appear to be associated with leaf litter under herbaceous cover. Some individuals have weak or no lamellae, leading to the varietal name *corneus*. The nominal species *Helix discrepans* was introduced by Pfeiffer (1863) for a depressed specimen collected by Rein. Gould (1991: 12) was probably referring to this species when he stated he found the "smallest and most cryptic" species of *Poecilozonites* alive in 1990.

This is the type species of *Gastrelasmus* Pilsbry (1924: 2).

Poecilozonites reinianus (Pfeiffer, 1863)
(Map 37, Fig. 38)

Helix reiniana Pfeiffer, 1863: 1 (Bermuda).

Helix Reinii [*sic*] Pfeiffer, - Rein, 1867: 77;
Helix Reiniana, - Pfeiffer, 1868: 172;
Hyalina Reiniana, - Jones, 1876: 138;
Patula reiniana, - Kobelt, 1880: 258, 286; Bland, 1881: 256;
Helix (group *Patula*, section *Discus*) *Reiniana*, - Tryon, 1887: 27;
Patula (Discus) reiniana, - Clessin in Pfeiffer, 1879: 91;
Poecilozonites reinianus var. *goodei* Pilsbry, 1889: 85, pl. 3, figs. 12, 13;
?Rotundatus, - Lane, 1891: 3 [non *Helix rotundatus* Müller, 1774];
Poecilozonites goodei, - Vanatta, 1911: 665; Peile, 1924: 18;
Poecilozonites reinianus, - Pilsbry, 1888: 290-291, pl. 17, fig I; Heilprin, 1889: 182; Bland, 1895: 270; Pilsbry, 1900: 500; Verrill, 1902: 728; Verrill, 1906: 164-165; Vanatta, 1911: 666; Vanatta, 1924: 7; Kutchka, 1934: 296; Hughes, post 1968: 1; Hughes, post 1969: 1;
Poecilozonites (Discozonites) reinianus, - Peile, 1924: 4, fig. 3 a-d; Peile, 1925: 258; Peile, 1926: 90; Riedel, 1980: 23;
Poecilozonites blandi Pilsbry, 1924: 2, 7-8, fig. 5 [introduction of genus-group name *Discozonites* with *P. blandi* as type species by original designation] (Bermuda), **new synonymy**;



Map 37. *Poecilozonites reinianus*.

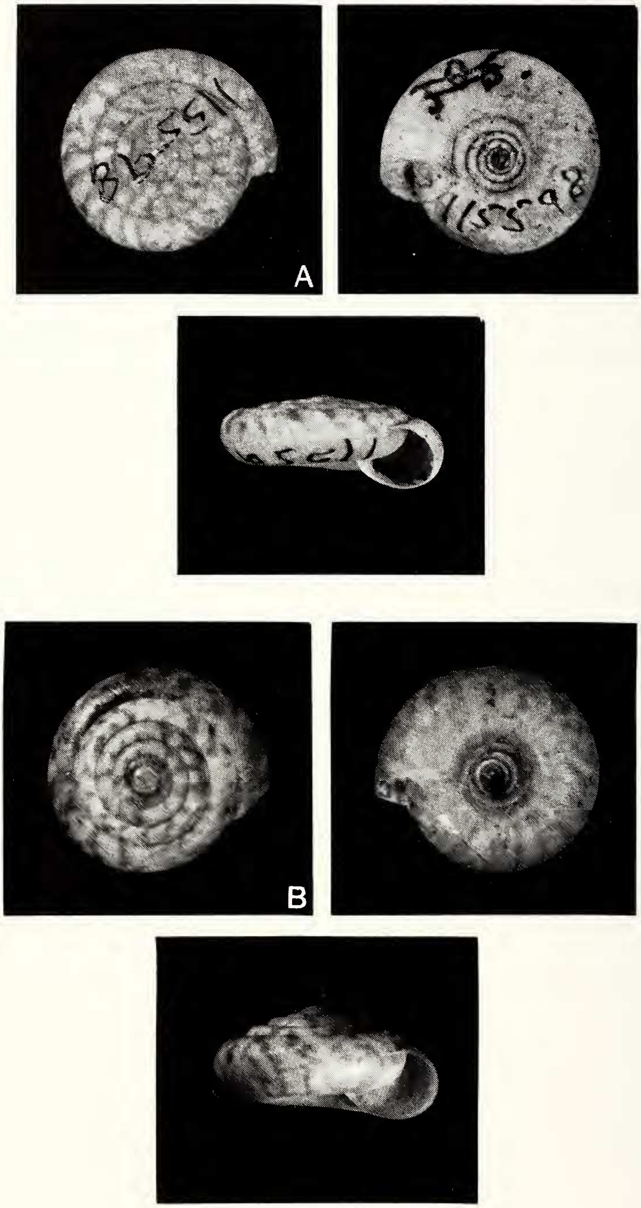


Figure 38. *Poecilozonites reinianus*. – 38a: FMNH 115598, Bermuda; diameter = 10.0 mm (apical view); diameter = 10.2 mm (basal view); diameter = 9.4 mm (apertural view). *Poecilozonites reinianus* "form blandi" – 38b: FMNH 45251, Bermuda; diameter = 8.9 mm.

Poecilozonites (Discozonites) blandi, – Peile, 1925: 258; Peile, 1926: 90; Thiele, 1931: 595; Zilch, 1959: 263, fig. 935 [after Pilsbry, 1924]; Riedel, 1980: 23.

Bermuda Material Studied: FMNH 16454, 45238, 45250 (fossil), 45251, 45252 (fossil), 45253 (fossil), 45254 (fossil), 71538, 115598.

Note: *Endemic* - Historically much less common and more restricted in range than *Poecilozonites bermudensis* and *P. circumfirmatus*, *P. reinianus* has only been collected on the eastern side of the main island of Bermuda. The varietal name *goodei* was introduced by Pilsbry (1889) for widely umbilicate and flattened shells that he wished to distinguish from narrowly umbilicate forms identified as *reinianus* in ANSP's collections. He mistakenly believed his narrowly umbilicate forms to be typical *reinianus* (Pilsbry, 1924). Pilsbry (1924) then synonymized *goodei* with *reinianus* and described *Poecilozonites blandi* for the narrowly umbilicate forms previously identified as *reinianus*. Umbilical width and the spire height of *P. reinianus* are surprisingly variable, as variable as in species of *Polygyra*. Separation of these two forms based on spire height and umbilical width alone is not possible as the full range of morphologies from tall narrowly umbilicate "*P. blandi*" to widely umbilicate "*P. reinianus*" *and* "*P. goodei*" exist in museum collections (FMNH 16454, 45238, 45251, 71538 and 115598). *Poecilozonites blandi*, the type species of *Discozonites* Pilsbry, 1924, is here synonymized with *Poecilozonites reinianus*.

This species was last reported alive by Peile (1926). Gould was unable to locate *P. reinianus* in 1973 (Gould, 1991: 12), as was this survey in 1988.

Striatura meridionalis (Pilsbry & Ferriss, 1906)
(Map 38, Fig. 39)

Vitrea (Striatura) milium meridionalis Pilsbry & Ferriss, 1906: 152-153 (Texas, New Mexico, Arizona).

Striatura milium meridionalis, – Vanatta, 1912: 12 (fossil);
Striatura milium v[ar]. *meridionalis*, – Peile, 1926: 89 (fossil);
Striatura meridionalis, – Pilsbry, 1946: 493-495 (fossil);
species A, – Gould, 1970b: 491;
Striatura (Pseudohyalina?) meridionalis, – Riedel, 1980: 23.

Bermuda Material Studied: ANSP 105793; FMNH 227041; MCZ Gould Station 4 (fossil), Gould Station 48 (fossil), Gould Station 63 (fossil).

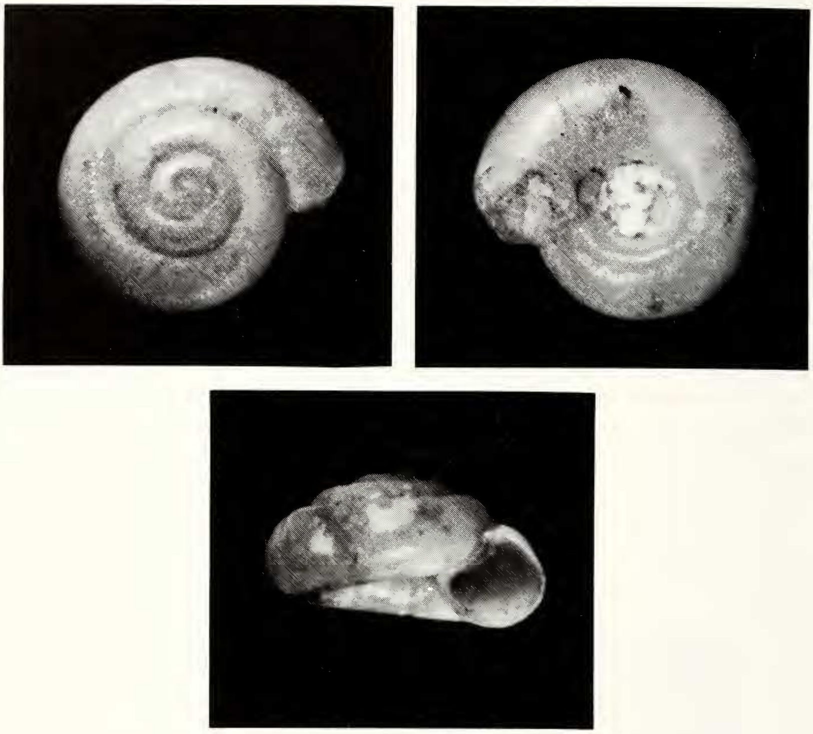
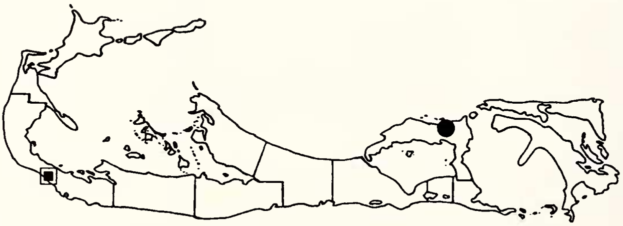


Figure 39. *Striatura meridionalis*. - ANSP 105793, Hamilton Parish, Bermuda; diameter = 1.68 mm.

Note: *Native Non-Endemic* - The paucity of live records of this species on Bermuda reflects its small size. Vanatta (1912) was the first to recognize this species from Bermuda. *Striatura meridionalis* is found in the southeastern United States (Maryland to Texas), in Mexico, and the Greater Antilles (van der Schalie, 1948). It lives in moist leaf litter.



Map 38. *Striatura meridionalis*.

Zonitoides arboreus (Say, 1816)
(Map 39, Fig. 40)

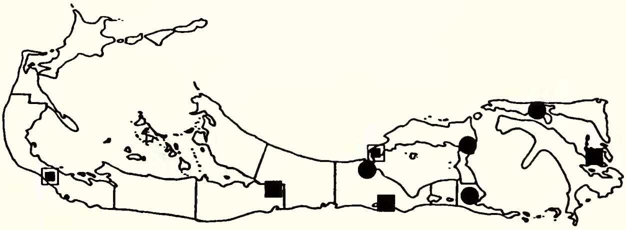
Helix arboreus [Say, 1816]: species no. 2, pl. 4, fig. 4 (North America).

Zonitoides arboreus, - Bryant, 1905: 130;
Zonitoides bermudensis Pilsbry & Vanatta, 1909: 63-64, fig. 1 a-d, **new synonymy**;
Zonitoides bermudensis, - Vanatta, 1924: 7; Vanatta, 1911: 665-667; Peile, 1926: 89.

Bermuda Material Studied: ANSP 91152, 100760, 99100, 131601, 85500, 110690, 113129, 85562; BAMZ 1998-166-081, 1998-166-114; DMNH 210277, 210258; FMNH 45024, 227050, 227051, 227052, 227053, 227054.

Note: *Accidentally Introduced* - The first record of *Zonitoides* on Bermuda came from a single lot collected by Stewerdson Brown in 1905. These specimens were used by Pilsbry & Vanatta (1909) to describe *Zonitoides bermudensis*, which is here synonymized with *Zonitoides arboreus* (Say, 1816).

In their description, Pilsbry & Vanatta cite the wide umbilicus of *Zonitoides bermudensis* as the main feature distinguishing it from *Z. arboreus*. However, Pilsbry (1946: 481) later demonstrated the variability of this character in *Zonitoides arboreus*, stating the "umbilicus [is] contained about 4 ½ to 5 times in the diameter." On the same page, measurements are given of a specimen from Williams County, Colorado, which is even more widely umbilicate (the umbilicus width fitting only four times in the shell diameter). Examination of the holotype and paratypes of *Zonitoides bermudensis* (ANSP 91152) collected by Brown reveals the holotype to be quite widely umbilicate. In fact, the holotype is among the most widely umbilicate of the hundreds of specimens collected by Brown, having a ratio of umbilical width to shell diameter of 0.338. A random sample of 50 of



Map 39. *Zonitoides arboreus*.

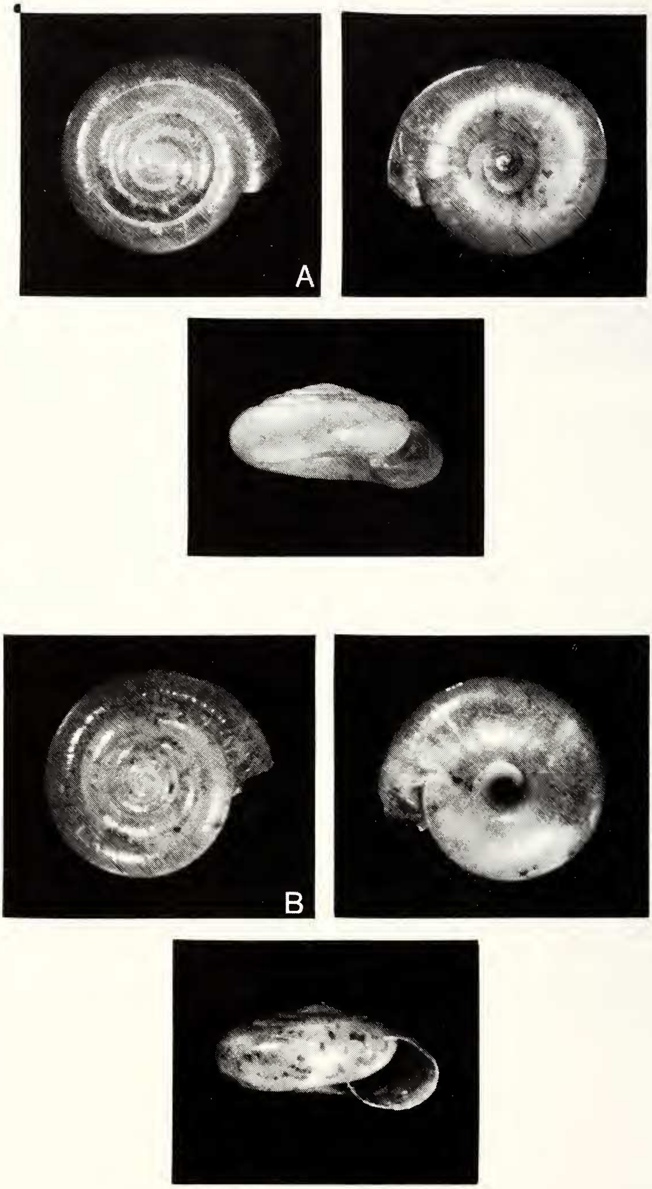


Figure 40. *Zonitoides arboreus*. – 40a: ANSP 91152, Holotype of *Zonitoides bermudensis* Pilsbry & Vanatta; diameter = 5.7 mm (body whorl damaged). – 40b: ANSP 91152, one of numerous paratypes of *Zonitoides bermudensis* Pilsbry & Vanatta; diameter = 4.6 mm.

the other specimens collected by Brown average only 0.265 umbilical width/diameter and can not be differentiated from widely umbilicate populations of *Zonitoides arboreus* from Missouri (FMNH 250319), New York (FMNH 250356), Tennessee (FMNH 250607, 250621), and Texas (FMNH 250638, 250640). Most of these widely umbilicate populations appear to occur in highly calcareous areas. The most widely umbilicate lot (FMNH 250621), like the lot collected by Brown from Bermuda, came from the vicinity of a cave. Other specimens collected from Bermuda (ANSP 85500, 110690, 113129; FMNH 227050, 227051, 227052, 227053, 227054) have the more "typical" morphology of *Zonitoides arboreus.*

Zonitoides arboreus is a native of North America and is found over most of the continent. It is also well known as an adventive species and has been recorded from South Africa, Hawaii, Japan and Australia (Pilsbry, 1946) and can often be found in potted plants. *Zonitoides* species are not found in Bermuda's abundant Pleistocene deposits. *Z. arboreus* is found under almost any type of cover and often is associated with rotting wood.

POLYGYROIDEA

POLYGYRIDAE

Patera appressa (Say, 1821)

(Map 40, Fig. 41)

Helix appressa Say, 1821: 151 ("banks of the Ohio and Missouri"; restricted to Ohio, Pilsbry, 1940: 751).

Helix Sancta Georgiensis Prime, 1853: 55 [*nomen nudum*];
Helix Sancta Georgiensis Jones, 1859: 107 [*nomen nudum*; based on Prime's list, but erroneously indicated as "n.s."];
Helix appressa, - Jones, 1876: 138; Bland, 1881: 256; Heilprin, 1889: 182 ; Lane, 1891: 2; Bland, 1895: 270;
Hex [*sic*] *appressa*, - Bartram, 1878: 108;
Triodopsis appressa, - Aldrich, 1889: 9;
Helix Sancta Georgiensis 'Bartram' - Lane, 1891: 2 [introduced in synonymy of *Helix appressa*];
Polygyra appressa, - Pilsbry, 1900: 496; Verrill, 1902: 730, 732, fig. 75d-f [with *H. sancta-georgiensis* in synonymy]; Pilsbry & Vanatta, 1924: 7;
Polygyra appressa sculptior Chadwick, 1899 [originally described as variety from Virginia], - Pilsbry, 1900: 496; Vanatta, 1911: 665; Peile, 1926;
Polygyra appressa var. *sanctaegeorgiensis* "(Prime), P. & V.", - Peile, 1926: 90;
Polygyra appressa var. *sculptior*, - Peile, 1926: 90;
Mesodon (*Patera*) *appressus* f. *sanctigeorgiensis* [*sic*] - Pilsbry, 1940: 751, fig. 452c;

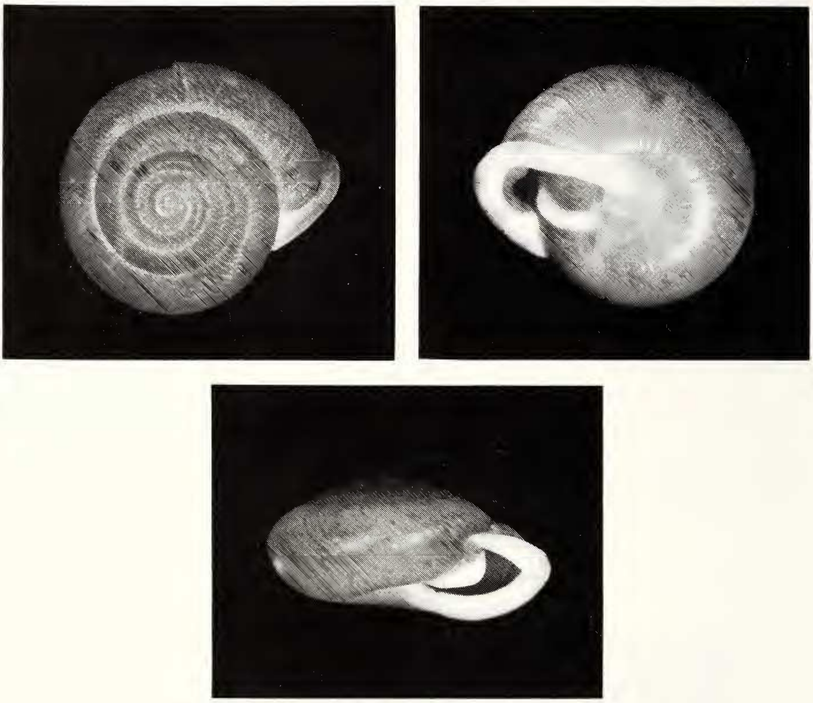
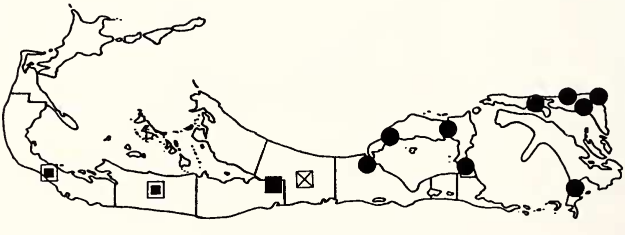


Figure 41. *Patera appressa.* – FMNH 29789, St. George's Parish, Bermuda; diameter = 13.3 (apical view); diameter = 13.0 mm (basal and apertural views).

Mesodon (*Patera*) *appressus* form *sanctageorgiensis* "'Prime' Verrill", – Pilsbry, 1940: 752.

Bermuda Material Studied: BAMZ 1998-166-001, 1998-166-008, 1998-166-016, 1998-166-029, 1998-166-042, 1998-166-047, 1998-166-115; DMNH 210241, 210250, 210280, 210312, 210320; FMNH 3639, 13484, 13525, 13533, 13539, 13583, 13592, 16460, 16461, 45850, 100191, 124505, 157504, 216047, 224768,



Map 40. *Patera appressa.*

224788, 224824, 224837, 224849, 224858, 224885, 224899.

Note: *Accidentally Introduced* - Native to the southeastern United States, from eastern Tennessee to eastern Virginia, this species was introduced to Bermuda before the first faunal survey of the islands. For many years it was restricted to the area around St. George, but it is now widespread on the larger islands of Bermuda. *Patera appressa* is often found in leaf litter in rocky areas and under cover in urban areas.

Polygyra plana (Dunker, 1843)
(Map 41, Fig. 42)

Helix plana Dunker in Philippi, 1843: 51-52, pl. 3, fig. 11 ("Indiae occidentales?").

Helix microdonta Deshayes [in Férussac & Deshayes], 1839, - Redfield, 1853: 17; Jones, 1859: 107; Bland, 1860: 93, 94; Tristram, 1861: 405; Bland, 1861: table 2, p. 351; Jones, 1864: 9; Bland, 1866: 360; Rein, 1867: 77; Jones, 1876: 138; Mörch, 1878: 3; Bland, 1881: 256; E. A. Smith, 1884: 277; Bland, 1895: 270 [*non Helix microdonta* Deshayes, 1832, teste Vanatta, 1911: 664];

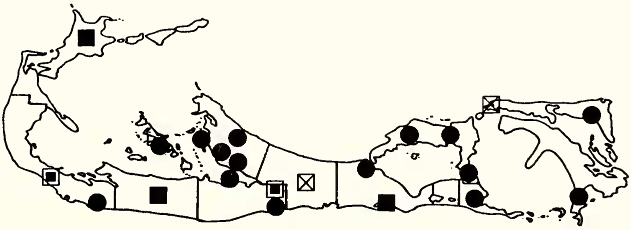
Helix cheilodon "Say MS." Bland, 1860: 94 [introduced as synonym of *H. microdonta sensu* Bland, from Bermuda);

Polygyra microdonta, - Kobelt, 1880: 258, 286; Pilsbry, 1900: 496, pl. 62, fig. 3; Verrill, 1902: 729, fig. 72; Gulick, 1904: 413; Hughes, post 1968: 1; Hughes, post 1969: 1;

Helix Ringens Lane 1891: 2, pl. 1, fig. 3 [plate not seen] (Bermuda) [*non Helix ringens* Linné, 1758: 769];

Helix (Polygyra) microdonta, - Heilprin, 1889: 182;

Polygyra plana, - Vanatta, 1911: 665-668 [citing Thiele *in litt.*; with *H. microdonta* Deshayes, 1839 in synonymy]; Honigmann, 1914: 375;



Map 41. *Polygyra plana*.

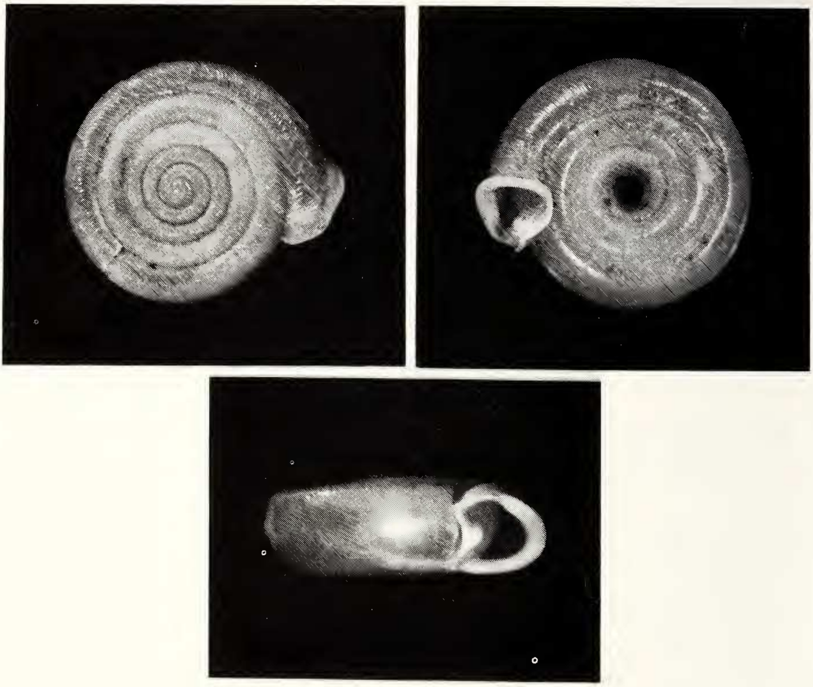


Figure 42. *Polygyra plana.* - FMNH 224888, Southampton Parish, Bermuda; diameter = 8.2 mm (apical and apertural views); diameter = 8.2 mm (basal view; different specimen).

Vanatta, 1923: 33; Peile, 1926: 90; Abbott, 1989: 134, fig.

Bermuda Material Studied: BAMZ 1998-166-003, 1998-166-010, 1998-166-027, 1998-166-074, 1998-166-096, 1998-166-100; DMNH 210262, 210272, 210284, 210306, 210314, 210322; FMNH 3640, 8834, 13517, 13535, 13545, 13551, 13564, 13573, 13593, 16459, 41023, 45687, 45778, 100168, 115647, 125209, 153255, 224781, 224800, 224801, 224851, 224867, 224873, 224888, 224894.

Note: *Accidentally Introduced* - A native of the Bahamas, this species arrived before the first faunal survey and is one of the few introduced species commonly found on the smaller island of Bermuda. It is very tolerant of salt spray and is found on dunes and in other open areas under cover.

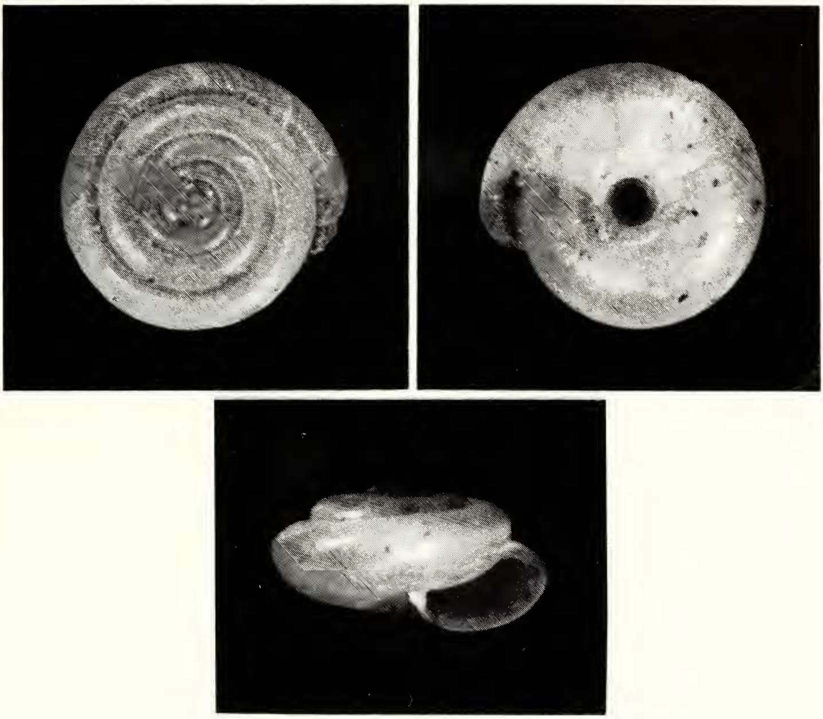


Figure 43. *Lacteoluna selenina.* – FMNH 224881, Southampton Parish, Bermuda; diameter = 5.2 mm (apical and apertural views); diameter = 4.8 mm (basal view).

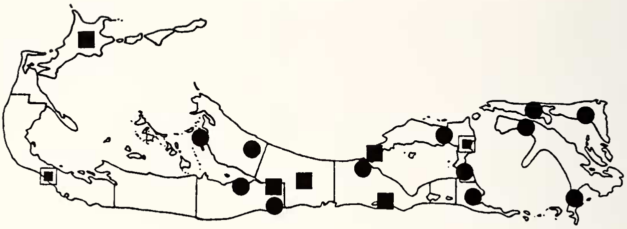
SAGDIDAE

Lacteoluna selenina (Gould, 1848)

(Map 42, Fig. 43)

Helix selenina Gould, 1848: 38 (Florida).

Helix selenina, – Prime, 1853: 55; Jones, 1859: 106;
Helix vortex Pfeiffer, 1839: 351 [*non Helix vortex* Linné, 1758] (Cuba);
Helix vortex, – Bland, 1861: table 2, p. 351; Rein, 1867: 77; Jones, 1876: 138; Bland, 1881: 256; E. A. Smith, 1884: 227;
Microphysa vortex, – Kobelt, 1880: 257, 286;
Helix (group *Patula*, section *Microphysa*) *vortex*, – Tryon, 1887: 98, pl. 19, figs. 25-28;
Helix (*Microphysa*) *vortex*, – Heilprin, 1889: 182;



Map 42. *Lacteoluna selenina.*

Patula vortex, – Bartram, 1878: 108; Bland, 1895: 270;

Thysanophora vortex, – Pilsbry, 1900: 495, pl. 62, fig. 1a, 1b; Verrill, 1902: 728, 229, fig. 70a, b; Gulick, 1904: 413; Peile, 1926: 90; Hughes, post 1969: 1;

Thysanophora selenina, – Vanatta, 1911: 665-668; Vanatta, 1923: 33;

Lacteoluna selenina, – Pilsbry, 1940: 981, 982.

Bermuda Material Studied: BAMZ 1998-166-017, 1998-166-022, 1998-166-043, 1998-166-084, 1998-166-111, 1998-166-122; DMNH 210279, 210329, 210332, 210334; FMNH 3638, 7607, 13486, 13515, 13529, 13540, 13561, 29784, 30198, 30199, 41017, 41018, 45560, 59080, 107033, 224765, 224784, 224807, 224808, 224821, 224834, 224842, 224845, 224856, 224881, 227022, 227031.

Note: *Accidentally Introduced* - One of the earliest introductions, *Lacteoluna selenina* was recorded by Prime (1853) as collected in 1852, and was reported from most surveys since, partly under its synonym *Helix vortex*, a preoccupied name. Hughes (post 1969; citing Gulick, 1904, and Gould, 1969) erroneously included this species in a listing of fossil species of Bermuda. This calciphile native of southern Florida and the West Indies is commonly found under stones and debris in woodlands.

THYSANOPHORIDAE

"Hojeda" hypolepta (Shuttleworth, 1854)

(Map 43, Fig. 44)

Helix hypolepta Shuttleworth, 1854: 129 (Bermuda).

Helix hypolepta, – Jones, 1876: 138;

?Helix hypolepta, – Heilprin, 1889: 182;

Patula hypolepta, – Bland, 1881: 256;

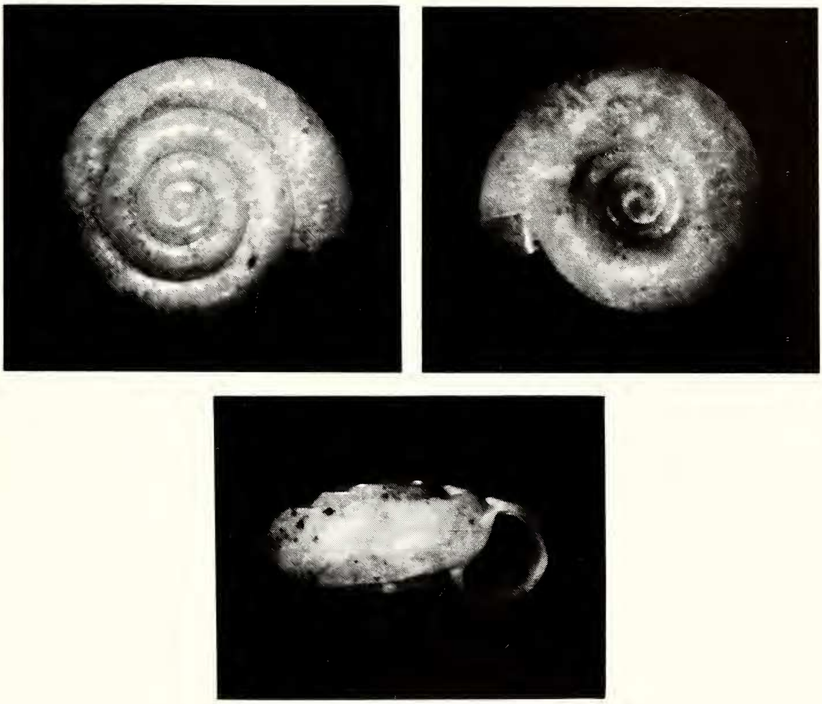
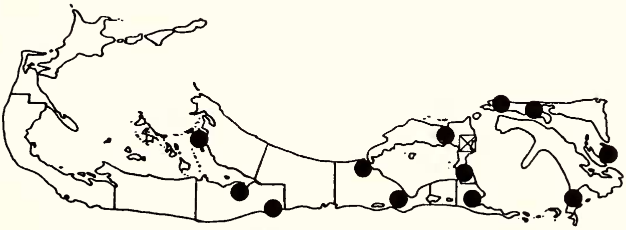


Figure 44. "*Hojeda*" *hypolepta*. – ANSP 100756, Paget Parish, Bermuda; diameter = 2.4 mm.

Helix (Microphysa) hypolepta, – Pilsbry, 1889: 82, pl. 3, figs. 6-8;
Patula (Thysanophora) hypolepta, – Bland, 1895: 270;
Lacteoluna hypolepta, – Haas, 1952: 104;
Thysanophora hypolepta, – Pilsbry, 1900: 496, pl. 62, fig. 2a, 2b; Verrill, 1902: 728, fig. 68a, b; Gulick, 1904: 413; Verrill, 1906: 169, fig. 52a; Vanatta, 1911: 666-667; Vanatta, 1912: 12; Vanatta, 1923: 33; Peile, 1926: 90; Hughes, post 1968: 1; Hughes, post 1969: 1; Gould, 1970b: 491, fig. 1a (fossil); Gould, 1970a: 572 (fossil); Gould, 1971a: 88;



Map 43. "*Hojeda*" *hypolepta*.

Hojeda hypolepta, – Richardson, 1986: 6.

Bermuda Material Studied: ANSP 100756; BAMZ 1995-132-021; FMNH 227021; MCZ Gould Station 1 (fossil), Gould Station 4 (fossil), Gould Station 11 (fossil), Gould Station 21 (fossil), Gould Station 21b (fossil), Gould Station 30 (fossil), Gould Station 41 east (fossil), Gould Station 48 (fossil), Gould Station 63 lower (fossil), Gould Station 73 (fossil).

Note: *Endemic* - The young of this species are very similar to *Hawaiia minuscula* and the two species were often confused in early surveys (Pilsbry, 1900). The anatomy of this species is unknown and shell characters cannot place it in any known genus. Its traditional familial placement within the Sagdidae or Thysanophoridae is also suspect. Based on shell characters alone this species might be equally well placed within the Helicodiscidae or Zonitidae. Pending anatomical studies, it is here provisionally placed in *Hojeda* Baker, 1926, following Richardson (1986). This species is found under rocks in open areas.

HELICOIDEA
BRADYBAENIDAE
Bradybaena similaris (Rang, 1831)
(Map 44, Fig. 45)

Helix similaris "Férussac" Rang, 1831: 15 (numerous localities).

Helix (Helicella) similaris Férussac, 1821: 43 [or p. 47, depending on issue] [*nomen nudum*];
Helix (Fruticicola) similaris, – Aldrich, 1889: 9;
Helix hortensis, – Lane, 1891: 2 [*non Helix hortensis* Müller, 1774: 52];
Eulota simularis [*sic*], – Olmsted, 1917: 225;
Eulota similaris, – Pilsbry, 1900: 495; Verrill, 1902: 734, fig. 82a-c; Vanatta, 1911: 665-668; Vanatta, 1923: 33;
Eulota (Eulota) similaris, – Honigmann, 1914: 376;
Eulota similis [*sic*], – Peile, 1926: 90.

Bermuda Material Studied: BAMZ 1998-166-009, 1998-166-030, 1998-166-048, 1998-166-050, 1998-166-059, 1998-166-070, 1998-166-075, 1998-166-093, 1998-166-119, 1998-166-121, 1998-166-124; DMNH 210243, 210244, 210248, 210253, 210291, 210296, 210299, 210321, 210325; FMNH 3635, 13488, 13491, 13505, 13514, 13522, 13534, 13546, 13562, 13590, 13678, 13685, 13688, 16468, 16469, 16470, 16471, 29792, 56551, 66154, 92867, 147322, 217509,

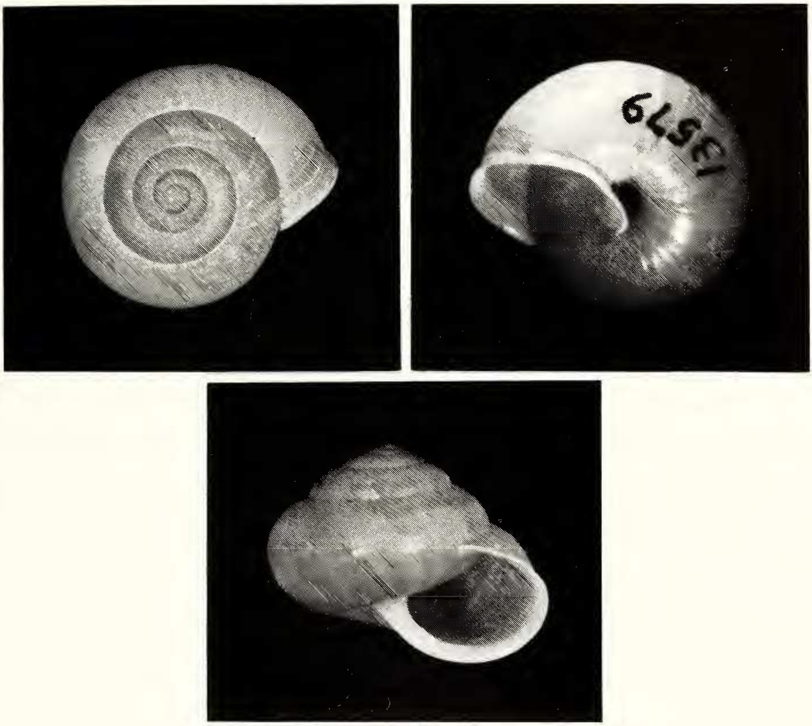
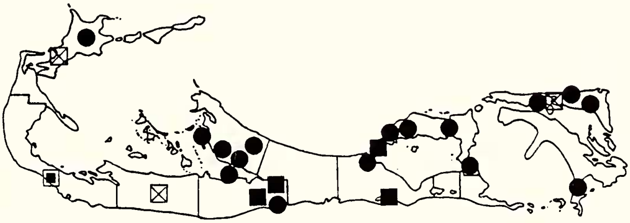


Figure 45. *Bradybaena similaris*. – FMNH 13579, Smith's Parish, Bermuda; diameter = 14.8 mm (apical view); diameter = 15.4 mm (basal and apertural views).

224758, 224769, 224782, 224802, 224818, 224829, 224877, 224895, 224904, 224915, 224916, 224917.

Note: *Accidentally Introduced* – First reported in 1889 by Aldrich, this species is one of the most common snails on Bermuda. Native to southeastern Asia, it is



Map 44. *Bradybaena similaris*.

widely introduced to subtropical and tropical regions including the southeastern United States (Dundee, 1970), the Caribbean, and southern Brazil.

COCHLICELLIDAE

Prietocella barbara (Linné, 1758)

(Map 45, Fig. 46)

Helix barbara Linné, 1758: 773 (North Africa).

Bulimus ventrosus (Férussac, 1821), - Prime, 1853: 55; Redfield, 1853: 17; Jones, 1859: 107; Bland, 1861: table 2; Jones, 1864: 9; Rein, 1867: 77; Jones, 1876: 139; Mörch, 1878: 3; E. A. Smith, 1884: 277; Frith, 1891: 15;

Bulimus ventricosus Draparnaud, 1801, - Tristram, 1861: 405 [*non Bulimus ventricosus* Bruguière, 1792];

Bullimus [*sic*] *ventrosus*, - Bartram, 1878: 108;

Helix ventricosa, - Jones, 1876: 138; Bland, 1881: 256; Bland, 1895: 271;

Cochlicella ventrosa, - Kobelt, 1880: 257, 286;

Helix (Cochlicella) ventricosa, - Heilprin, 1889: 182;

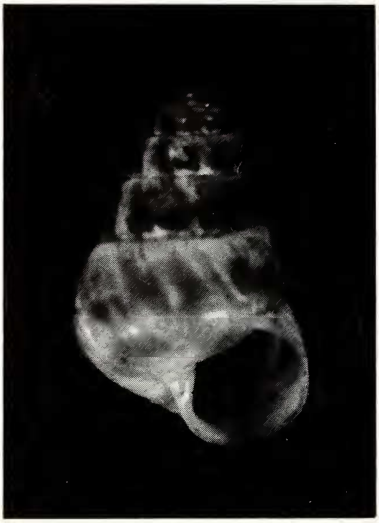
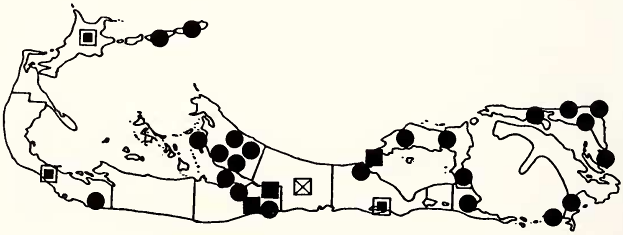


Figure 46. *Prietocella barbara*. - FMNH 16472, St. George's Parish, Bermuda; height = 6.6 mm.



Map 45. *Prietocella barbara*.

Helicella (Cochlicella) ventricosa, – Pilsbry, 1900: 494;

Helicella ventricosa, – Verrill, 1902: 732, 733, fig. 79a-d; Vanatta, 1911: 665-668; Vanatta, 1923: 33;

Cochlicella barbara, – Glaubrecht, 1990: 218;

Prietocella barbara, – Schileyko & Menkhorst, 1997: 54 [for placement in *Prietocella*].

Bermuda Material Studied: BAMZ 1998-166-033, 1998-166-036, 1998-166-044, 1998-166-079, 1998-166-095, 1998-166-097, 1998-166-101; DMNH 210245, 210266, 210301, 210307, 210317; FMNH 3636, 3637, 4034, 13487, 13498, 13508, 13513, 13523, 13536, 13543, 13554, 13566, 13570, 13682, 16472, 29789, 41021, 102461, 124907, 125197, 217430, 224756, 224765, 224779, 224797, 224819, 224830, 224871, 224878, 224918, 224919, 227058.

Note: *Accidentally Introduced* - Recorded in the first survey of Bermuda, and in nearly every other survey, this snail is very common on Bermuda. *Prietocella barbara* is native to the Mediterranean region and has been introduced into North America to California and the Carolinas. It is often found in large numbers on bushes and on bark at the base of trees.

HELICIDAE

Otala lactea (Müller, 1774)

(Map 46, Fig. 47)

Helix lactea Müller, 1774: 19-20 (Europe).

Otala lactea, – Bennett & Hughes, 1959: 432; Hughes, 1962; Hughes, 1963; Simmonds & Hughes, 1963: 219-221; Hughes (post 1968): 1; Gould, 1969: 419; Monkman, 1982a: 1; Monkman, 1982b: 71; Bennett et al., 1985: 138; Cock, 1985: 138; Abbott, 1989: 191, fig.; Glaubrecht, 1990: 220, fig. 10.

Bermuda Material Studied: BAMZ 1994-118-002, 1995-133-001, 1998-166-035, 1998-166-054, 1998-166-064, 1998-166-069, 1998-166-106; DMNH 210246, 210289, 210292, 210295, 210315; FMNH 224763, 224775, 224791, 224836, 224867, 224883, 224912, 227002, 227003, 227004, 227005.

Note: *Accidentally Introduced* - This native of southern Spain and northern Africa is a common food snail in markets around the world and has also been introduced

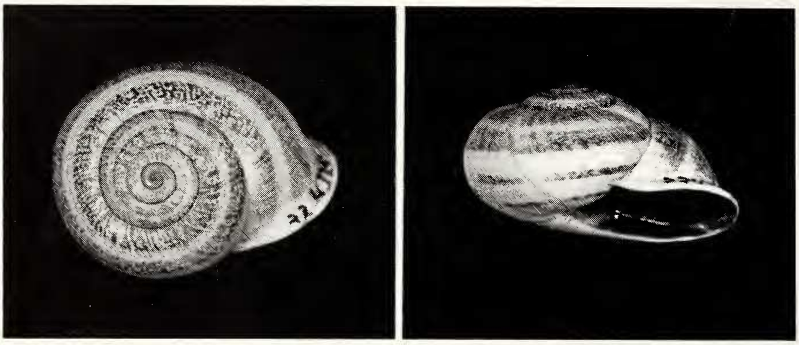
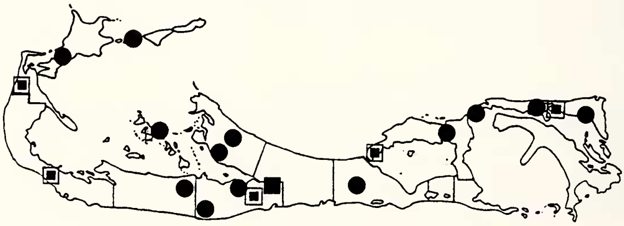


Figure 47. *Otala lactea.* – FMNH 224775, Paget Parish, Bermuda; diameter = 33.8 mm (apical view); diameter = 33.9 mm (apertural view).

to North America. In 1928, *Otala lactea* was introduced to Fairylands, Bermuda, reportedly by crawling out of a bag purchased from the New York Fulton Fish Market for food (Gould, 1969: 419, citing personal communication with Hughes). By the 1950s, it was widespread and considered a horticultural pest by the Bermuda Department of Agriculture. *Otala lactea* was the primary impetus for the release of several predatory snails on Bermuda (Bennett & Hughes, 1959). Initial very optimistic reports of successful control by the predatory species (Simmonds & Hughes, 1963; Hughes, post 1968; mirrored by Godan, 1983: 325, who called it a "great success") were followed by surveys showing little or no control of *Otala* populations (Monkman, 1982a). The current survey finds *Otala lactea* to be one of the most common species of snails on Bermuda, easily found aestivating in bushes throughout the larger islands of Bermuda.



Map 46. *Otala lactea.*

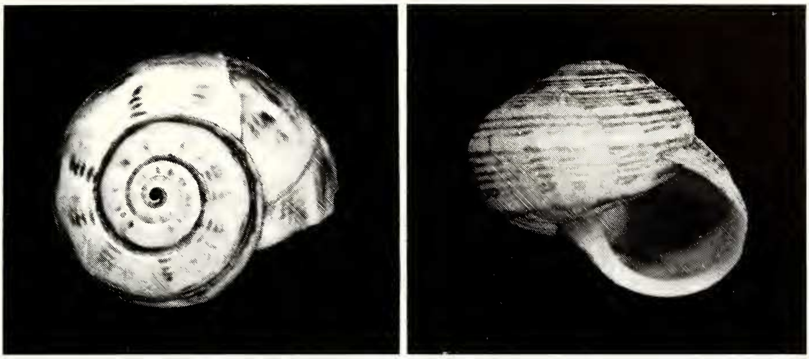


Figure 48. *Theba pisana*. - BAMZ 1995-133-005, St. George's Parish, Bermuda; diameter = 22.2 mm (apical view); diameter = 22.8 mm (apertural view).

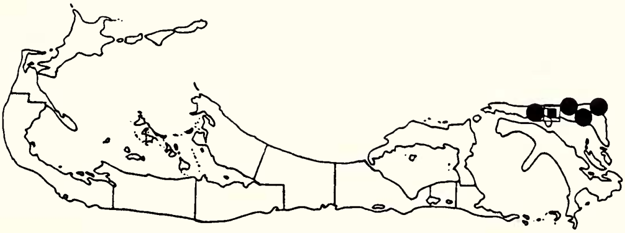
Theba pisana (Müller, 1774)
(Map 47, Fig. 48)

Helix pisana Müller, 1774: 60-61 (Europe).

Helix pisana, - Davis, 1904: 126; Vanatta, 1911: 665;
Euparypha pisana, - Peile, 1926: 90.

Bermuda Material Studied: BAMZ 1995-133-005, 1998-166-063; DMNH 210293; FMNH 16467, 29790, 29791, 227018.

Note: *Accidentally Introduced* - This common Mediterranean species was first recorded around the city of St. George by Davis (1904) who attributed his record to the Verrill party of 1898. *Theba pisana* has also been introduced to Australia, South Africa and western North America. On Bermuda it is one of the few introduced species that have a restricted range. To date it has only been found



Map 47. *Theba pisana*.

within a few miles of the city of St. George on St. George's Island. Live individuals can be found aestivating on the stems of bushes.

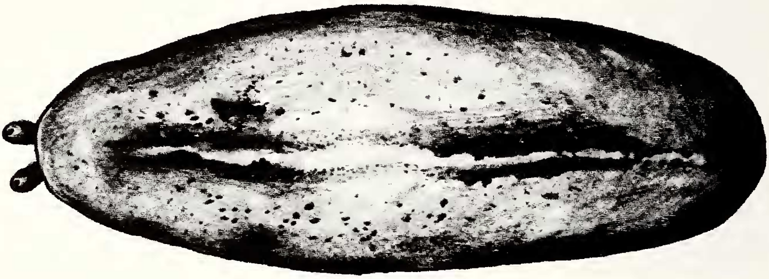


Figure 49. *Leidyula sloanii.* - FMNH 224876, Southampton Parish, Bermuda; dorsal view; body length = 29 mm.

SYSTELLOMMATOPHORA: RATHOUISOIDEA

VERONICELLIDAE

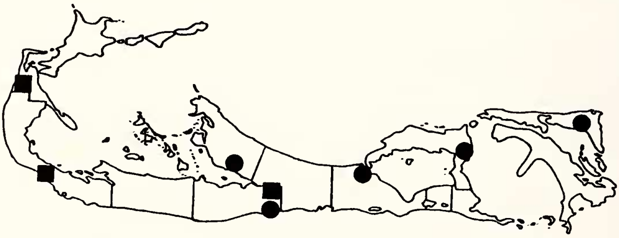
Leidyula sloanii (Cuvier, 1816)

(Map 48, Fig. 49)

Onchidium Sloanii Cuvier, 1816: 411 (Jamaica).

Vaginulus sp., - Pilsbry 1888: 288;
Vaginulus schivelyae Pilsbry, 1890b: 297, pl. 5, figs. 6-8 (Bermuda);
Vaginulus schivelyae, - Pilsbry, 1891: 39, pl. 2, figs. 6-8;
Veronicella schivelyae, - Pilsbry, 1900: 502; Verrill, 1902: 728, 735, figs. 84, 1a-c; Peile, 1926: 90; Hughes, post 1968: 1;
Veronicella schivelyoe [*sic*], - Olmsted, 1917: 224;
Veronicella sloanii schivelyae, - H. B. Baker, 1925: 160-163, pl. 3, figs. 1-4.

Bermuda Material Studied: BAMZ 1998-166-116; FMNH 3642, 13668, 30211,



Map 48. *Leidyula sloanii.*

30212, 59481, 224760, 224868, 224876.

Note: *Accidentally Introduced* - This species was first recorded from specimens collected "in the Public Garden at St. George" by the Heilprin party in 1888 (Pilsbry, 1888; 1890b: 298). It is commonly found at night, crawling on walls and garden fences.

Bermuda specimens were described as *Vaginulus schivelyae* Pilsbry, 1890, and thought endemic to Bermuda until compared to specimens of Jamaican *Leidyula sloanii* by Baker (1925). Hoffmann (1927: 215) argued in contrast that, pending further anatomical observations, Pilsbry's *V. schivelyae* could be conspecific with *Leidyula floridana* (Leidy, 1851), *L. moreleti* (Crosse & Fischer, 1872), or *L. olivacea* Stearns, 1871. The group needs additional study and is here listed under the earliest name of the complex.

Several singular or doubtful records exist:

Achatina fulica Bowdich, 1822: A snail collected in May of 1971 from Dock Hill, Devonshire Parish, was identified by staff of the Department of Agriculture as *Achatina fulica* from a photograph published in a local newspaper (Hughes, 1971). However, the snail apparently was not preserved. Specimens of *Achatina* were not located in collections at the Bermuda Department of Agriculture or in the Natural History Museum, Bermuda, and no further specimens have been reported.

Mesodon zaletus (Binney, 1837): A single series of three specimens of this eastern North American species were found in the collections of the Natural History Museum, Bermuda (BAMZ 1995-132-024). However, this large-shelled species was not found during this survey and no locality information was associated with the museum material.

Cerion spp.: ***Cerion maritimum*** (Pfeiffer, 1839) was listed by Prime (1853: 77, as *Pupa*). Jones (1864: 9) referred to Bermuda material "found by Mr. Marrett on the Port Royal Hills" as "***Pupa chrysalis*?**" (apparently based on *Cerion mumia* var. *chrysalis* Férussac, from Cuba, Guadeloupe and Martinique). One specimen of ***Cerion variabile*** Dall, 1905, was collected by Louis Mowbry in 1926 from beach drift and reported by Gray (1942). No other specimens of this genus, live or dead, have been recorded, and no *Cerion* population seems to be established on the islands.

Limax maximus Linné, 1758 - Recorded by Hughes (post 1968a), this large slug does not appear in the collections of either the Bermuda Department of

Agriculture or the Natural History Museum, Bermuda. This record is probably a misidentification of *Limacus flavus*.

Cepaea nemoralis (Linné, 1758) - The European Garden Snail was reported for Bermuda by Lane (1891, Essay 1; as *Helix nemoralis*), but has not been found since. Verrill (1902: 734) suggested this record to be an error for *Poecilozonites bermudensis*, whereas Vanatta (1911: 665) and we interpreted it as an error for *Bradybaena similaris*.

Succinea putris*, *Pupa troquilla pyrenaearia [sic], and ***Pachystyla mauritiana* var.** were listed for Bermuda by Bartram (1878: 108). Bartram misidentified his material by direct comparison with Chenu's illustrations of European specimens in the 'Manuel Conchyliologie.' Bartram was probably referring to *Succinea bermudensis*, *Gastrocopta pellucida*, and *Poecilozonites bermudensis*.

Unavailable names mentioned in the Bermuda literature:

"*Helix somersetii*"

Helix Somersetii Prime, 1853: 55 [*nomen nudum*];
"*H[elix] Somersetii* (n.s.)" Jones, 1859: 106-107 [based on Prime's list; *nomen nudum*].

"*Bulimus bermudensis*"

Bulimus Bermudensis Prime, 1853: 55 [*nomen nudum*];
"*B[ulimus] Bermudensis* (n.s.)" Jones, 1859: 107 [based on Prime's list; *nomen nudum*].

Neither name was validly introduced and neither can be unequivocally assigned to any one species.

DISCUSSION

Bermuda's fauna, with few terrestrial animals, has long been considered depauperate and disharmonious (Verrill, 1902). However, the 17 species of terrestrial mollusks native to Bermuda (see Table 1) are slightly more than might be expected from an island group of such limited size (54 km^2 or 19.5 mi^2) and low elevation (75 m or 245 ft). Pacific islands of similar size and elevation, for example, average only 12.5 species (Solem, 1990: table 5). As was pointed out before, land snail diversity does not seem to be well predicted by island size and counter-intuitively rises with distance from a colonization source (Solem, 1974). The high levels of species diversity observed on isolated islands are largely due to extensive species radiations of rarely successful colonists, as can be seen in the Achatinellidae of Hawaii or *Poecilozonites* of Bermuda. However, many of Bermuda's native land snails, 6 of 17, are native non-endemics and the abundance of these is perplexing when Bermuda's isolation and traditional views of the low dispersal ability of snails are taken into consideration. Several plausible scenarios have been proposed to explain such dispersal ability of snails, including wind dispersal (Peake, 1981: 250), rafting (Pilsbry, 1900), and dispersal on migratory birds (Dundee *et al.*, 1967). Small snails would be more likely to be transported by these means than larger snails. It is no surprise then, that Gould (1970b: 490) doubted "that any other factor beyond size is required to explain why the pulmonate fauna of Bermuda, an assemblage of chance immigrants, includes such a preponderance of small forms." However, size may not be the only factor determining the unusual species composition of Bermuda's land snail fauna: Many of Bermuda's native genera of land snails are known to contain species having the ability to produce young uniparentally, for example *Carychium* (Bulman, 1990) and *Vertigo* (Pokryszko, 1987), or have anatomy suggestive of self-fertilization as in *Poecilozonites* (Pilsbry, 1889: 85).

All eleven species endemic to Bermuda share their closest affinities with species of eastern North America (see notes under each species), with the possible exception of "*Hojeda*" *hypolepta* whose relationship with other species is unknown. Antillean affinities reported by Pilsbry (1900) are based in part on several species now known to have been introduced accidentally. The six native non-endemic species all have widespread distributions that are remarkably similar and include the extreme southeast coast of North America, and in most cases the Greater Antilles as well.

The majority of Bermuda's terrestrial mollusks are very widely distributed, are closely associated with human activities, and do not have a fossil history on Bermuda, leading to the generalized conclusion they are accidentally introduced through commerce. In fact, at least eleven of these species have also been accidentally introduced to the Hawaiian Islands (Cowie, 1997) and 21 are known traveling species often encountered by the Animal and Plant Health Inspection Service of the United States Department of Agriculture (Robinson, 1999). The high proportion of synanthropic mollusks on Bermuda (28 of 49 species) mirrors the high proportions in some of Bermuda's other terrestrial animal groups, such as Coleoptera ("nearly all the beetles have been introduced accidentally by human activity"; Hilburn & Gordon, 1989: 674) and spiders (53 of 59 species; Sierwald, 1988). Of the 28 introduced snail species, nine or ten are native to Europe and North Africa, ten are native to Tropical America, four or five are native to North America, two to Asia, one to Africa, and one to the Pacific Ocean Basin. Because

Table 1. Terrestrial mollusk species occurrences on Bermuda by date of survey.

Key to Symbols:
□ Recent
■ Recent Live-Collected
● Fossil
See notes in species listings for additional information about dates of introduction.

Endemic Species																
Carychium bermudense	●	-	-	-	-	-	-	-	-	-	-	□	■	■	-	■
"Euconulus" turbinatus	●	-	-	-	-	-	-	-	-	-	-	■	-	■		
"Hojeda" hypolepta	●	-	-	-	-	-	-	□	□	-	-	□	□	■	-	□
Poecilozonites bermudensis	●	□	□	□	□	□	□	□	■	-	□	□	□	■	■	□
Poecilozonites circumfirmatus	●	□	□	□	□	□	□	□	■	-	□	□	□	■	■	■
Poecilozonites reinianus	●	-	-	-	□	-	-	□	■	-	□	□	□	■		
Punctum bristoli	●	-	-	-	-	-	-	-	-	-	-	-	■	■	-	■
Succinea bermudensis	●	□	□	□	□	□	□	□	□	-	□	□	□	□	■	■
Vertigo bermudensis	●	-	-	-	-	-	-	-	-	-	-	□	-	□		
Vertigo marki	●	-	-	-	-	-	-	-	-	-	-	□	-	■		
Vertigo numellata	●	-	-	-	-	-	-	-	-	-	-	□	□	■	-	■
Date of survey*	fossil	1852	1859	1861	1867	1873	1878	1881	1888	1895	1898	1910	1922	1926	1950	1988

Native Non-Endemic Species																
Gastrocopta pellucida	●	-	□	□	□	-	-	□	□	□	□	■	□	□	■	■
Gastrocopta rupicola	●	-	-	-	-	-	-	-	□	-	□	■	□	□	■	■
Pupisoma macneilli	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	■
Pupoides albilabris	●	-	□	□	□	-	□	□	□	□	□	□	-	□		
Striatura meridionalis	●	-	-	-	-	-	-	-	-	-	-	-	-	■	-	■
Strobilops hubbardi	●	-	-	-	-	-	-	-	-	-	-	□	□	■	-	□
Date of survey*	fossil	1852	1859	1861	1867	1873	1878	1881	1888	1895	1898	1910	1922	1926	1950	1988

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*Key to Survey Dates, Collectors and Sources:
Fossil collected by A. Gulick and S. J. Gould (Gulick, 1904; Gould 1970b)
1852 collected by T. Prime (Prime, 1853; Pilsbry 1900)
1859 (pre-1860) collected by T. Prime and J. M. Jones (Jones, 1859)
1861 (pre-1862) collected by Governor F. Murray (Tristram, 1861)
1867 (pre-1868) collected by J. J. Rein and Governor C. B. Ord's sons (Rein, 1867)
1873 collected by the Challenger Expedition (Smith, 1884; Pilsbry, 1900)
1878 (pre-1879) collected by J. T. Bartram and an un-named gentleman from Hamilton (Bartram, 1878)

Table 1. (continued)

Accidentally Introduced Species															
Opeas hannense															■
+*Streptostele musaecola*															■
Tornatellides sp.															■
Otala lactea													1928	-	■
Helicodiscus singleyanus													☐	-	■
Allopeas gracile											☐	-	☐	-	■
Allopeas micrum											☐	-	☐	-	■
Theba pisana											☐	-	☐	■	■
Zonitoides arboreus											■	-	☐	-	■
Gastrocopta servilis										☐	☐	-	☐	☐	
Limacus flavus										■	-	-	☐		
Bradybaena similaris								1889	-	■	☐	☐	☐	■	■
Gulella bicolor								☐							
Leidyula sloanii								☐	☐	■	-	-	☐	■	■
Obeliscus swiftianus								☐	-	☐	-	☐	☐	■	■
Rumina decollata						☐	-	■	☐	☐	☐	☐	☐	■	■
Deroceras laeve					☐	-	-	-	☐	-	☐	-	☐	-	■
Milax gagates					☐	-	-	-	☐	■	■	-	☐	-	■
Oxychilus draparnaudi				☐	-	-	-	-	-	-	■	-	☐	-	■
Subulina octona				☐	-	-	☐	☐	☐	☐	☐	-	☐	■	■
Ceciliodes acicula			☐	-	-	☐	☐	-	☐	☐	☐	-	☐	-	☐
Polygyra plana	1852	☐	☐	☐	☐	-	☐	☐	-	■	■	☐	☐	■	■
Prietocella barbara	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	-	■	■
Hawaiia miniscula	☐	-	-	-	-	-	-	-	-	☐	■	☐	☐	■	■
Lacteoluna selenina	☐	☐	☐	☐	☐	☐	☐	☐	-	☐	■	☐	☐	■	■
Oligyra convexa	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	■	■
Patera appressa	☐	☐	-	-	-	☐	☐	☐	-	■	■	-	☐	■	■
Vallonia pulchella	☐	☐	☐	☐	-	-	☐	-	☐	-	☐	-	☐		
Date of survey*	1852	1859	1861	1867	1873	1878	1881	1888	1895	1898	1910	1922	1926	1950	1988

1881 (pre-1882) collected by C. B. Adams, T. Prime, R. Swift, T. Bland (Bland, 1881)
1888 collected by the Heilprin Expedition (Heilprin, 1889; Pilsbry 1900)
1895 (pre-1896) collected by C. B. Adams, T. Prime, R. Swift, T. Bland (Bland, 1895)
1898 collected by the Verrill Expedition (Pilsbry, 1900)
1910 (1905-1910) collected by S. Brown, E. E. and E. G Vanatta (Vanatta, 1911)
1922 collected by H. Hoyt (Vanatta, 1924; Vanatta, 1924)
1926 (pre-1927) collected by A. J. Peile & A. Haycock (Peile, 1926)
1950 collected by F. Haas (FMNH collections; Haas 1952)
1988 (1983 & 1988) collected by R. Bieler *et al.*
+An additional record from the Fahy Collection, 1992.

human activities have carried these species throughout the world, tracing a single point-of-origin for Bermuda's populations of each species (if only one exists) is probably impossible. Three of these species are recorded here for the first time (*Streptostele musaecola*, *Opeas hannense* and *Tornatellides* sp.). Such species introductions, although nearly tripling the number of land snail species on Bermuda, have not lead to saturation and subsequent species turnover. Solem's (1990: 112) assertion that, given time and appropriate conditions, land snail species can accumulate sympatrically to a level of more than 60 species (postulated for natural colonization of Pacific islands) might soon be proved true also for the in part "artificial" colonization of Bermuda.

Unfortunately, the similarities between Bermuda and the Pacific Islands have continued with the deliberate introduction of four predatory snail species for biological control. The earliest reports of declines in abundance in *Poecilozonites* came in the late 1960's (Gould 1969). Subsequent authors (e.g., Glaubrecht 1990) attributed the reduction in *Poecilozonites* to competition with the introduced species *Otala lactea* and *Rumina decollata*. However, *Rumina* had been introduced nearly a century earlier and *Otala* more than 40 years before, and noticeable reductions in population numbers were not observed until the period between 1963 and 1969. It is more likely that the introduction of the predatory species *Euglandina rosea* in late 1958 was responsible (see Table 1). *Euglandina* is now widespread on the larger islands of Bermuda, with the possible exception of the southeastern portion of the main island. *Gonaxis quadrilateralis* is just beginning to spread beyond its original release sites, and *Otala* and *Rumina* are among the most common and widespread snails on Bermuda, with little evidence of control by *Euglandina*. *Poecilozonites*, on the other hand, has become quite uncommon and appears to be threatened by extinction. Only two of the three extant species of this endemic genus were found during this survey and neither of these is common: *P. circumfirmatus* was found alive in two localities and fresh-dead specimens of *P. bermudensis* were found in another. Several endemic and native non-endemic species including *Poecilozonites reinianus*, *Vertigo marki*, *Vertigo bermudensis* and *Strobilops hubbardi* appear to be restricted to the southeastern portion of the main island near caves and remnant stands of native vegetation.

It is hoped that this work represents another stepping stone in the informal series investigating the history of Bermuda's mollusk fauna, and – most importantly – that it provides the necessary baseline data for continued monitoring of a rapidly changing faunal composition.

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LITERATURE CITED

Abbott, R. T. 1989. Compendium of landshells. A color guide to more than 2,000 of the world's terrestrial shells. American Malacologists, Inc., Melbourne, Florida and Burlington, Massachusetts. viii+ 240 pp.

Adams, C. B. 1841. "Ward's letter." American Journal of Science, 40: 271.

Adams, C. B. 1845. Specierum novarum conchyliorum, in Jamaica repertorum, synopsis. Proceedings of the Boston Society of Natural History, 2: 1-17 [January].

Adams, C. B. 1849. Descriptions of supposed new Helicidae from Jamaica. Contributions to Conchology, no. 3: 33-38.

Albers, J. C. 1850. Die Heliceen, nach natürlicher Verwandtschaft systematisch geordnet. T. C. F. Enslin, Berlin. 262 pp.

Albers, J. C. 1860. Die Heliceen, nach natürlicher Verwandtschaft systematisch geordnet. Zweite Ausgabe [second edition, edited by E. von Martens]. W. Engelmann, Leipzig. xviii + 359 pp.

Aldrich, T. H. 1889. *H. (Fruticola) similaris*, Fer., *Triodopsis appressa*, Say, *Stenogyra decollata*, L., in Bermuda. The Nautilus, 3(1): 9.

Ancey, C. F. 1887. Description of new genera or subgenera of Helicidae. The Conchologists' Exchange, 1(9-10): 53-54.

Ancey, C. F. 1903. Études sur la faune malacologique des Iles Sandwich, 5^{e} Partie. Journal de Conchyliologie, 51(4): 295-307, pl. 12.

Angas, G. F. 1884. On the terrestrial Mollusca of Dominica, collected during a recent visit to that island. Proceedings of the Scientific Meetings of the Zoological Society of London, for the year 1883, part 4: 594-597 [April 1884].

Auffenberg, K. & L. A. Stange. 1986. Snail-eating snails of Florida. Entomology Circular No. 285, 4 pp.; Florida Department of Agriculture and Consumer Services, Division of Plant Industry.

Baker, H. B. 1922. Notes on the radula of the Helicinidae. Proceedings of the Academy of Natural Sciences of Philadelphia, 74: 29-67, pls. 3-7 [8 August].

Baker, H. B. 1925. Nomenclature of Veronicellidae (Vaginulidae). The Nautilus, 39(1): 13-18 [8 July].

Baker, H. B. 1926. North American Veronicellidae. Proceedings of the Academy of Natural Sciences of Philadelphia, 77: 157-184, pls. 3-6.

Bartram, J. T. 1878. Sea and land shells of Bermuda. Bermuda Almanack and Directory 1878, pp. 105-108.

Beck, H. 1837-1838. Index Molluscorum praesentis aevi Musei Principis Augustissimi Christiani Frederici. Pp. 1-100, 1837; pp. 101-124 and appendix (8 pp.), 1838. Hafniae.

Bennett, F. D. & I. W. Hughes. 1959. Biological control of insect pests in Bermuda. Bulletin of Entomological Research, 50(3): 423-434.

Bennett, F. D., M. J. W. Cock, I. W. Hughes, F. J. Simmonds & M. Yaseen. 1985. Biological control in Bermuda. pp. 119-142 *in* Cock, M. J. W. (ed.). A review of biological control of pests in the Commonwealth Caribbean and Bermuda up to 1982. Commonwealth Institute of Biological Control Technical Communication No. 9.

Bequaert, J. C. & W. B. Miller. 1973. The mollusks of the arid southwest with an Arizona check list. The University of Arizona Press, Tucson. xvi + 271 pp.

Binney, A. 1837-1841. A monograph of the Helices inhabiting the United States. Boston Journal of Natural History , 1: 466-495 (May 1837); 3: 353-394 (July 1840); 405-438 ("November 1840") [dates *teste* A. A. Gould, 1851: 9; but last part dated as 1841 by Turgeon et al., 1998: 147, 294].

Binney, A. 1842. Descriptions of some of the species of naked, air-breathing Mollusca, inhabiting the United States. Boston Journal of Natural History, 4(2): 163-175.

Binney, W. G. 1876. On the lingual dentition, jaw, and genitalia of *Carelia*, *Onchidella*, and other Pulmonata. Proceedings of the Academy of Natural Sciences of Philadelphia for 1876: 183-192, pl.6.

Binney, W. G. 1884. Notes on the jaw and lingual dentition of pulmonate mollusks. Annals of the New York Academy of Sciences, 3: 79-136, pls. 2-17.

Bland, T. 1860. Remarks on certain species of North American Helicidae. Annals of the Lyceum of Natural History in New York, 7: 69-95.

Bland, T. 1861. On the geographical distribution of the genera and species of land shells of the West India islands; with a catalogue of the species of each island. Annals of the Lyceum of Natural History of New York, 7: 335-362.

Bland, T. 1866. Remarks on the origin and distribution of the operculated land shells which inhabit the continent of America and the West Indies, with a catalogue of the American species. American Journal of Conchology, 2(1): 54-63, 2(2): 136-143, 2(4): 349-370 [subsequent parts with variant titles].

Bland, T. 1875. Notes on certain terrestrial mollusks, with descriptions of new species. Annals of the Lyceum of Natural History of New York, 11(1876): 72-87 [February 1875].

Bland, T. 1881. List of the land shells of Bermuda. Pp. 256-257 in: A. R. Wallace, Island life; or, the phenomena and causes of insular faunas and floras, including a revision and attempted solution of the problem of geological climates. New York, Harper & brothers; xvi + 522 pp.

Bland, T. 1895. List of the land-shells of Bermuda. Pp. 270-271 in: A. R. Wallace, Island life; or the phenomena and causes of insular faunas and floras, including a revision and attempted solution of the problem of geological climates. Second and revised edition. London, MacMillan and Co.; xx + 563 pp.

Bland, T. & W.G. Binney. 1873. On the lingual dentition of certain terrestrial Pulmonata foreign to the United States. Annals of the Lyceum of Natural History of New York, 10(1872): 219-225 [January 1873].

Boettger, O. 1884. Lebende Vertreter zweier Hochheimer untermiocäner Landschnecken. Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie, 2: 139.

Bourguignat, J.-R. 1925. Dates des livraisons de l'Histoire des Mollusques de Férussac et Deshayes, vérifées d'après le registre de l'éditeur Baillière, de Paris. Journal de Conchyliologie, 69: 15-18.

Brown, A. D. 1861. Description of two new species of *Helix*. Proceedings of the Academy of Natural Sciences of Philadelphia, 1861: 333.

Brown Jr., W. L. 1987. Punctuated equilibrium excused: the original examples fail to support it. Biological Journal of the Linnean Society, 31: 383-404.

Bruguière, [J.-G.]. 1789-1792. Encyclopédie méthodique. Histoire naturelle des vers. Tome 1. Panckoucke, Paris; Plomteux, Liège. xviii + 757 pp. [pp. 1-344, June 1789; pp. 345-757, 13 February 1792; *teste* Cowie 1998].

Bryant, O. 1905. Some notes on Bermudian mollusks. The Nautilus, 18(11): 129-131.

Bulman, K. 1990. Life history of *Carychium tridentatum* (Risso, 1826) (Gastropoda: Pulmonata: Ellobiidae) in the laboratory. Journal of Conchology, 33(6): 321-333.

Chadwick, G. H. 1899. Notes on *Polygyra appressa*. The Nautilus, 13(5): 54-55.

Clapp, G. H. 1918. New southern forms of *Carychium* and *Thysanophora*. The Nautilus, 31(3): 73-75, pl .8.

Clarke, B., J. Murray & M. S. Johnson. 1984. The extinction of endemic species by a program of biological control. Pacific Science, 38(2): 97-104.

Clench, W. J. & R. D. Turner. 1962. New names introduced by H. A. Pilsbry in the Mollusca and Crustacea. Academy of Natural Sciences of Philadelphia Special Publication, 4: 1-218.

Cock, M. J. W. 1985. A review of biological control of pests in the Commonwealth Caribbean and Bermuda up to 1982. Technical Communication, Commonwealth Institute of Biological Control, 9: xii + 218 pp. (ISBN 0851985505).

Cowan, C. F. 1969. Cuvier's Règne animal, First Edition. Journal of the Society for the Bibliography of Natural History, 5(3): 219.

Cowie, R. H. 1997. Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands. Bishop Museum Occasional Papers, 50: 1-66.

Cowie, R. H. 1998. Catalog of the nonmarine snails and slugs of the Samoan Islands. Bishop Museum Bulletin in Zoology, 3: viii + 122 pp. [13 January].

Cuvier, [G.] ["1817"] 1816. Le règne animal distribué d'après son organisation, pour servir de base a l'histoire naturelle des animaux et d'introduction a l'anatomie comparée. Tome II, cotenant les reptiles, les poissons, les mollusques et les annélides. Deterville, Paris. xviii + 532 pp. [7 December 1816, *teste* Cowan, 1969].

da Costa, E. M. 1778. Historia naturalis testaceorum Britanniae, or, the British conchology; containing the descriptions and other particulars of natural history of the shells of Great Britain and Ireland: illustrated with figures. In English and French. Da Costa, London. xii + 254 + viii pp., 17 pls.

Davis, C. A. 1904. Notes on the Mollusca of the Bermuda Islands. The Nautilus, 17(11): 125-130, pl. 4.

Davis, C. J. & G. D. Butler, Jr. 1964. Introduced enemies of the Giant African Snail, *Achatina fulica* Bowdich, in Hawaii (Pulmonata: Achatinidae). Proceedings of the Hawaiian Entomological Society, 18(3): 377-389.

Deisler, J. E. & R. T. Abbott. 1984. Range extensions of some introduced land mollusks in the Bahama Islands, with first reports for four species. The Nautilus, 98(1): 12-17.

Deshayes, G. P. 1832. Encyclopédie méthodique. Histoire naturelle des vers..., 2 (FRI-MYT): 145-594 [29 September].

Draparnaud, J. 1801. Tableau des mollusques terrestres et fluviatiles de la France. Renaud, Montpellier; Bossange, Masson & Besson, Paris. 116 pp. [14 July].

Draparnaud, J.-P.-R. 1805. Histoire naturelle des mollusques terrestres et fluviatiles de la France. Louis Colas, Paris. i-viii, 1-164 pp., pls. 1-13 [posthumously published].

Drouët, H. 1859. Essai sur les mollusques terrestres et fluviatiles de la Guayane Française. J.-B. Baillière, Paris. 109 pp., 4 pls.

Dundee, D. S. 1970. Introduced Gulf Coast molluscs. Tulane Studies in Zoology and Botany, 16(3): 101-115.

Dundee, D. S., P. H. Philipps & J. D. Newsom. 1967. Snails on migratory birds. The Nautilus, 80(3): 89-91.

Eldredge, N. & S. J. Gould, 1972. Punctuated equilibria: an alternative to phyletic gradualism. pp. 82-115. In: T. J. M. Schopf (ed.), Models in Paleobiology. Freeman, Cooper & Company, San Francisco. 250 pp.

Ellis, A. E. 1951. Proposed addition to the "Official List of Specific Trivial Names in Zoology" of the names of certain non-marine species in the phylum Mollusca. Bulletin of Zoological Nomenclature, 2(4): 125-128.

Fechter, R. & G. Falkner. 1990. Weichtiere. Europäische Meeres- und Binnenmollusken. Steinbachs Naturführer (G. Steinbach, ed.), Mosaik Verlag, Munich. 287 pp.

Ferguson, D.C., D.J. Hilburn & B. Wright. 1991. The Lepidoptera of Bermuda: their food plants, biogeography, and means of dispersal. Memoirs of the Entomological Society of Canada, 158: i-ii, 1-105.

Férussac, D. de. 1821-1822. Tableaux systématiques des animaux mollusques classés en familles naturelles, dans lesquels on a établi la concordance de tous les systèmes; suivis d'un prodrome générale pour tous les mollusques terrestres ou fluviatiles, vivants ou fossiles. A. Bertrand, Paris, and J. B. Sowerby, London. i-xlviii, 1-27, 1-110 [+i] pp. [published in issues; see Sherborn & Woodward, 1901, and Cowie, 1998, for dates].

Férussac, de [A. E. J. P. J. F. d'A.] 1823. P. 96ζ in de Férussac & G.-P. Deshayes, 1820-1851. Histoire naturelle générale et particulière des mollusques terrestres et fluviatiles tant des espèces que l'on trouve aujourd'hui vivantes, que des dépouilles fossiles de celles qui n'existent plus; classés d'après les caractères essentiels que présentent ces animaux et leurs coquilles, Tome 2., Paris, J.-B. Baillière; xvi + 260 pp., 247 pls.

Férussac, D. de & G.-P. Deshayes. 1819-1851. Histoire naturelle générale et particulière des mollusques terrestres et fluviatiles tant des espèces que l'on trouve aujourd'hui vivantes, que des dépouilles fossiles de celles qui n'existent plus; classés d'après caractères essentiels que présentent ces animaux et leurs coquilles. Baillière, Paris. Issued in 42 parts. [see Sherborn

& Woodward, 1901; Bourguignat, 1925, and Kennard, 1942, for individual dates].

Fisher, T. W., R. E. Orth & S. C. Swanson. 1980. Snail against snail. California Agriculture (Nov. - Dec.): 3 pp.

Fischer [von Waldheim], G. 1807. Museum Demidoff, ou, Catalogue systématique et raisonnée des curiosités de la nature et de l'art: données à l'Université Impériale de Moscou par son ecellence Monsieur Paul de Demidoff. Volume 3. Imprimerie de l'Université Imperiale, Moscow. Frontispiece, ix + 330 pp., 6 pls.

Frith, M. A. M. 1891. Essay [3]. Pp. 14-18 (with copies of letters by Jones and Bartram), in: Five essays as furnished to the Board of Agriculture in response to an advertisement offering prizes for the descriptions of and the history of the Spiral Snails, and the most efficacious, expeditious, and economical methods to effect their extermination. Gregory V. Lee, Queen's Printer, Hamilton, Bermuda.

Gerber, J. 1996. Revision der Gattung *Vallonia* Risso 1826 (Mollusca: Gastropoda: Valloniidae). Schriften zur Malakozoologie aus dem Haus der Natur - Cismar, 8: 1-227.

Giusti, F., G. Manganelli & P. J. Schembri. 1995. The non-marine molluscs of the Maltese Islands. Museo Regionale de Scienze Naturali, Torino, Monografie XV:1-607.

Glaubrecht, M. 1990. Bermuda - ein evolutionärer Mikrokosmos im Atlantik? Zur Naturgeschichte einer isolierten Inselgruppe. Natur und Museum, 120(7): 209-222.

Godan, D. 1983. Pest slugs and snails - biology and control. Springer-Verlag, Berlin, Heidelberg, New York. x + 445 pp.

Gould, A. A. 1843. Monograph of the species of *Pupa* found in the United States [continued]. Boston Journal of Natural History, 4(3): 350-360, pl. 16.

Gould, A. A. 1848. Untitled. ["Dr. Gould had recently examined the Shells collected by Mr. J. Bartlett, in the south-western States, for the late Dr. Binney... He gave descriptions of the following..." (p. 37)]. Proceedings of the Boston Society of Natural History, 3: 37-41.

Gould, A. A. (editor). 1851. The terrestrial air-breathing mollusks of the United States, and the adjacent territories of North America: described and illustrated by Amos Binney. Vol. 1. C.C. Little & J. Brown, Boston. xxix + 366 pp.

Gould, S. J. 1966. Allometry in Pleistocene land snails from Bermuda: the influence of size upon shape. Journal of Paleontology, 40(5): 1131-1141.

Gould, S. J. 1968. Ontogeny and the explanation of form: an allometric analysis. Journal of Paleontology, 42(5), part 2 of 2: 81-98, pl. 10.

Gould, S. J. 1969. An evolutionary microcosm: Pleistocene and Recent history of the land snail P. (*Poecilozonites*) in Bermuda. Bulletin of the Museum of Comparative Zoology, 138(7): 407-531, frontispiece, pls. 1-5 [December].

Gould S. J. 1970a. Coincidence of climatic and faunal fluctuations in Pleistocene Bermuda. Science, 168: 527-573 [May].

Gould, S. J. 1970b. Land snail communities and Pleistocene climates in Bermuda: a multivariate analysis of microgastropod diversity. Proceedings of the North American Paleontological Convention (Field Museum of Natural History, Chicago, September 5-7, 1969), 1(part E): 486-521 [October].

Gould S. J. 1971a. Environmental control of form in land snails: a case of unusual precision. The Nautilus, 84(3): 86-93 [January].

Gould S. J. 1971b. Precise but fortuitous convergence in Pleistocene land snails from Bermuda. Journal of Paleontology, 45(3): 409-418 [May].

Gould S. J. 1991. Unenchanted evening. Natural History, 9/91: 4-14.

Gray, A. F. 1942. A *Cerion* found in Bermuda. The Nautilus, 55(3): 104.

Guilding, L. 1828. Observations on the zoology of the Caribaean islands [continued]. The Zoological Journal, 3: 527-544, pls. 15, 26 (Supp.), 27 (Supp.), 28 (Supp.).

Gulick, A. 1904. The fossil land shells of Bermuda. Proceedings of the Academy of Natural Sciences of Philadelphia, 56: 406-425, pl. 36.

Haas, F. 1952. On the mollusk fauna of the landlocked waters of Bermuda. Fieldiana, Zoology, 34(8): 101-105.

Hadfield, M. G. & B. S. Mountain. 1981. A field study of a vanishing species, *Achatinella mustelina* (Gastropoda, Pulmonata), in the Waianae Mountains of Oahu. Pacific Science, 34(4) [1980]: 345-358.

Hanna, G. D. 1966. Introduced mollusks of western North America. Occasional Papers of the California Academy of Sciences, 48: 1-108, pls. 1-4.

Hastings, G. R. 1892. The broken-tail snail in Bermuda [and reply by C. V. Riley and L. O Howard]. Insect Life, 4(9-10): 334.

Heilprin, A. 1889 ["With additions by Prof. J. Playfair McMurrich, Mr. H. A. Pilsbry, Dr. George Marx, Dr. P. R. Uhler, and Mr. C. H. Bollman"]. The Bermuda Islands: a contribution to the physical history and zoology of the Somers Archipelago: with an examination of the structure of coral reefs: researches undertaken under the auspices of the Academy of Natural Sciences of Philadelphia. Heilprin, Philadelphia. 231 pp., 17 pls.

Hilburn, D. J. & R. D. Gordon. 1989. Coleoptera of Bermuda. Florida Entomologist, 72: 673-692.

Hoffmann, H. 1927. On some North American Vaginulidae. Proceedings of the Academy of Natural Sciences of Philadelphia, 79: 209-212.

Honigmann, L. 1914. Beitrag zur Landmolluskenfauna der Bermudas. Zoologischer Anzeiger, 44(8): 375-377 [June].

Hubricht, L. 1985. The distribution of the native land mollusks of the eastern United States. Fieldiana, Zoology, (NS) 24: i-viii, 1-191.

Hughes, I. W. (unpublished report, 1962). Annual Report of the Assistant Director of Agriculture for the year ending 31st December, 1962.

Hughes, I. W. (unpublished report, 1963). Annual Report of the Assistant Director of Agriculture for the year ending 31st December, 1963.

Hughes, I. W. (post 1968). Recent terrestrial mollusks of Bermuda. Department of Agriculture and Fisheries, Bermuda; 3 pp. handout.

Hughes, I. W. (post 1969). Fossil land snails of Bermuda. Department of Agriculture and Fisheries, Bermuda; 2 pp. handout.

Hughes, I. W. 1971. Giant African snail. Monthly Bulletin of the Bermuda Department of Agriculture and Fisheries, 41(6): 48.

Hutton, T. 1834. On the land shells of India. Journal of the Asiatic Society of Bengal, 3: 81-93.

ICZN (International Commission on Zoological Nomenclature). 1955. Opinion 336. Additions to the "Official List of Specific Names in Zoology" of the specific names of one hundred and twenty-two non-marine species of the phylum Mollusca. Opinions and Declarations rendered by the International Commission on Zoological Nomenclature (F. Hemming, ed.), 10(3): 77-108.

ICZN (International Commission on Zoological Nomenclature). 1994. Opinion 1766. *Tortaxis* Pilsbry, 1906 and *Allopeas* Baker, 1935 (Mollusca, Gastropoda): conserved by the designation of a neotype for *Achatina erecta* Benson, 1842. Bulletin of Zoological Nomenclature, 51(2): 162-163.

Johnson, C. W. 1900. Some notes on *Rumina decollata* Linn. The Nautilus, 13(10): 117.

Jones, J. M. 1859. The naturalist in Bermuda; a sketch of the geology, zoology, and botany, of that remarkable group of islands; together with meteorological observations. Reeves & Turner, London. xii + 200 pp., 1 map [we have been unable to locate an "1852" edition of this work as cited by some authors].

Jones, J. M. 1864. Contributions to the natural history of the Bermudas. Part I. Mollusca. J. Bowes & Sons, Halifax. 13 pp. [also found cited as Transaction Nova Scotian Institute of Natural Science of Halifax, N.S. 1(2): 14-26; not seen].

Jones, J. M. 1876. Mollusca. The visitor's guide to Bermuda, with a sketch of its natural history. 156 pp., 5 woodcuts, Reeves & Turner, London.

Karlin, E. J. & J. A. Naegele. 1966. Biology of the Mollusca of Greenhouses in New York State. Cornell University Agricultural Station Memoir, 372: 1-35.

Kennard, A. S. 1942. The Histoire and Prodrome of Férussac. Proceedings of the Zoological Society of London, 25(1): 12-17.

Kerney, M. P. & R. A. D. Cameron. 1979. A field guide to the land snails of Britain and North-West Europe. Collins, London; 288 pp., 24 pls.

Kinzie III, R. A. 1992. Predation by the introduced carnivorous snail *Euglandina rosea* (Férussac) on endemic aquatic lymnaeid snails in Hawaii. Biological Conservation, 60: 149-155.

Kobelt, W. 1880. Die geographische Verbreitung der Mollusken (Schluss). Jahrbücher der Deutschen Malakozoologischen Gesellschaft, 7(3): 241-286 [July].

Krauss, N. L. H. 1964. Investigation on biological control of Giant African (*Achatina fulica*) and other land snails. The Nautilus, 78(1): 21-27.

Kutchka, G. M. 1934. Notes on the fossil land shells from Bermuda in the collection of the Carnegie Museum. Annals of the Carnegie Museum, 22(2-4): 293-302, pls. 19-21.

Lamarck, [J. B. P. A. de Monet de] 1822. Histoire naturelle des animaux sans vertèbres, présentant les caractères généraux et particuliers de ces animaux, leur distribution, leurs classes, leurs familles, leurs genres, et la citation des principales espèces qui s'y rapportent ..., 6(2): 232 pp.; Lamarck, Paris [April].

Lane, W. G. 1891. The spiral snails of Bermuda. [Essay 1] Pp. 1-8, in: Five essays as furnished to the Board of Agriculture in response to an advertisement offering prizes for the descriptions of and the history of the Spiral Snails, and the most efficacious, expeditious, and economical methods to effect their extermination. Gregory V. Lee, Queen's Printer, Hamilton, Bermuda.

Lea, I. 1841. On fresh water and land shells. Proceedings of the American Philosophical Society, 2(17): 30-35.

Leidy, J. 1851. Special anatomy of the terrestrial Gasteropoda of the United States. Pp. 198-248, pls. 1-16 *in*: Gould, A. A. (ed.), The terrestrial air-breathing mollusks of the United States, and the adjacent territories of North America: described and illustrated by Amos Binney. Vol. I. Charles C. Little & James Brown, Boston.

Linné, C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. 12th ed. Volume 1. Stockholm. 824 pp.

Manganelli, G. & F. Giusti. 1997. *Helix draparnaudi* Beck, 1837 (currently *Oxychilus draparnaudi*; Mollusca, Gastropoda): proposed conservation of the specific name. Bulletin of Zoological Nomenclature, 54(3): 148-151.

Martens, E. von. 1889. Eine ausgestorbene Landschnecke von den Bermuda-Inseln. Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin, 17 December 1889, pp. 201-202.

Mazÿck, W. G. 1889. Note on *Helix Bermudensis*, Pfeiffer. Proceedings of the Elliott Society, 1888: 210-211 [19 March 1889].

Monkman. D. 1982a. Distribution of predaceous snails *Euglandina rosea* and *Gonaxis quadrilateralis* in Bermuda. Unpublished report, Department of Agriculture and Fisheries, Bermuda.

Monkman, D. 1982b. On the trail of the snail. Monthly Bulletin of the Department of Agriculture and Fisheries, Bermuda, 53(9): 70-72.

Moquin-Tandon, A. 1855. Histoire naturelle des mollusques terrestres et fluviatiles de France contenant des études générales sur leur anatomie et leur physiologie et la description particulière des genres, des espèces et des variétés. Atlas. J-B. Baillière, Paris. 54 pls.

Mörch, O. A. L. 1878. Catalogue of West-India shells in the collection of Dr. C. M. Poulsen. Bianco Luno, Copenhagen. 16 pp.

Morelet, A., 1860. Description de nouvelles espèces de l'Afrique occidentale, rapportées par M. le capitaine Vignon. Journal de Conchyliologie, 8: 189-191 [April].

Morrison, J. P. E. 1953. Two new American species of *Strobilops*. The Nautilus, 67(2): 53-55, pl. 6 [October].

Müller, O. F. 1774. Vermium terrestrium et fluviatilium, seu animalium infusoriorum, helminthicorum, et testaceorum, non marinorum, succincta historia. Volume 2. Möller, Copenhagen and Leipzig. [i-xxxv], 1-214 pp., index [215-224].

Murray, J., E. Murray, M. S. Johnson & B. Clarke. 1989. The extinction of *Partula* on Moorea. Pacific Science, 42(3-4) (1988): 150-153 [January].

Naggs, F. 1989. *Gulella bicolor* (Hutton) and its implications for the taxonomy of streptaxids. Journal of Conchology, 33(3): 165-168, pl. 18 [June].

Naggs, F. 1992. Case 2833. *Tortaxis* Pilsbry, 1906 and *Allopeas* Baker, 1935 (Mollusca, Gastropoda): proposed conservation by the designation of a neotype for *Achatina erecta* Benson, 1842. Bulletin of Zoological Nomenclature, 49(4): 258-260.

Naggs, F. 1994. The reproductive anatomy of *Paropeas achatinaceum* and a new concept of *Paropeas* (Pulmonata: Achatinoidea: Subulinidae). Journal of Molluscan Studies, 60(2): 175-191.

Olmsted, J. M. D. 1917. Notes on the locomotion of certain Bermudian mollusks. The Journal of Experimental Zoology, 24(2): 223-236.

Orbigny, A. d'. 1835. Synopsis terrestrium et fluviatilium molluscorum, in suo per Americam merdionalem itinere, ab A. D'Orbigny, collectorum. Magasin de Zoologie, 5, Classe V, no. 61 [terrestrial mollusks]: [1]-22.

Orbigny, A. d'. 1841-1846. Mollusques. In: Ramon de la Sagra: Histoire physique, politique et naturelle de l'Ile de Cuba. - 1: 208, pls. 1-14 (1841); 209-264, pls. 15-17 (1842); 2: 1-112, pls. 1-7 (1842); 113-380, pls.8-24 ("1846", 1853?); Atlas (1842) [fide Keen, 1971]; A. Bertrand, Paris.

Oughton, J. 1948. A zoogeographical study of the land snails of Ontario. University of Toronto Studies, Biological Series, no. 57: i-xi, 1-128, 2 tables.

Peake, J. F. 1981. The land snails of islands – a dispersalist's viewpoint (chapter 19). Pp. 247-263 in: The evolving biosphere (P. L. Forey, ed.), Chance, change & challenge (P. H. Greenwood, gen. ed.). British Museum (Natural History), Cambridge University Press.

Peile, A. J. 1924. Notes on the genus *Poecilozonites*; with descriptions of new species. Proceedings of the Malacological Society of London, 16(1): 16-23.

Peile, A. J. 1925. Further notes on *Poecilozonites*. Proceedings of the Malacological Society of London, 16(5): 257-258.

Peile, A. J. 1926. The Mollusca of Bermuda. Proceedings of the Malacological Society, London, 17(2-3): 71-98.

Peniston, A. 1891. Essay [5]. Pp. 21-22, in: Five essays as furnished to the Board of Agriculture in response to an advertisement offering prizes for the descriptions of and the history of the Spiral Snails, and the most efficacious, expeditious, and economical methods to effect their extermination. Gregory V. Lee, Queen's Printer, Hamilton, Bermuda.

Pfeiffer, L. 1839. Bericht über die Ergebnisse meiner Reise nach Cuba im Winter 1838-1839. [Wiegmann's] Archiv für Naturgeschichte, 5(1): 346-358.

Pfeiffer, L. 1840. Uebersicht der im Januar, Februar und März 1839 auf Cuba gesammelten Mollusken. [Wiegmann's] Archiv für Naturgeschichte, 6(1): 250-261.

Pfeiffer, L. 1841a. Symbolae ad historiam heliceorum. T. Fischer, Kassel. 100 pp.

Pfeiffer, L. 1841b. Beiträge zur Molluskenfauna Deutschlands, insbesondere der österreichischen Staaten. Archiv für Naturgeschichte, 7(1): 215-230.

Pfeiffer, L. 1845. Description of twenty-two new land-shells, belonging to the collection of Mr. H. Cuming. Proceedings of the Zoological Society of London, 13: 63-69 (September).

Pfeiffer, L. 1847-1848. Monographia Heliceorum viventium. Sistens descriptiones systematicas et criticas omnium huius familiae generum et specierum hodie cognitarum. Vol. 1. F. A. Brockhaus, Leipzig. xxxii + 484 pp.

Pfeiffer, L. 1849. Description of twenty-nine new species of *Helicina*, from the collection of H. Cuming. Proceedings of the Zoological Society of London, 16 (1848): 119-125 [25 April 1849].

Pfeiffer, L. 1852. Uebersicht des gegenwärtigen Zustandes der Heliceenkunde (Schluss). Zeitschrift für Malakozoologie, 9(10): 145-151.

Pfeiffer, L. 1853. Diagnosen neuer Heliceen. Zeitschrift für Malakozoologie, 10(4): 51-58.

Pfeiffer, L. 1857. Descriptions of thirty-one new species of land-shells, from Mr. Cuming's Collection. Proceedings of the Zoological Society of London, 25: 107-113 [August-September].

Pfeiffer, L. 1859. Monographia Heliceorum viventium. Sistens descriptiones systematicas et criticas omnium huius familiae generum et specierum hodie cognitarum. Vol. 4. F. A. Brockhaus, Leipzig. 920 pp.

Pfeiffer, L. 1863. Zwei neue Landschnecken von Bermuda. Malakozoologische Blätter, 11(1864): 1-2.

Pfeiffer, L. 1868. Monographia Heliceorum viventium. Sistens descriptiones systematicas et criticas omnium huius familiae generum et specierum hodie cognitarum. Vol. 5. F. A. Brockhaus, Leipzig. xii + 565 pp.

Pfeiffer, L. 1879-1881 [posthumous, edited by S. Clessin]. Nomenclator Heliceorum viventium quo continetur nomina omnium hujus familiae generum et specierum hodie cognitarum disposita ex affinitate naturali. T. Fischer, Kassel. Parts 1-6, pp. 1-384 (1879); 617 pp. (1881).

Philippi, R. A. 1843. *Helix* Tab. III. Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien, unter Mithülfe mehrerer deutscher Conchyliologen herausgegeben, 1(3): 47-52, pl. 3.

Pilsbry, H. A. *The following dates of publication for H.A. Pilsbry are all teste Clench & Turner (1962):*

Pilsbry, H. A. 1888. On the helicoid land molluscs of Bermuda. Proceedings of the Academy of Natural Sciences of Philadelphia, 40: 285-291, pl. 17 (December) [also printed in Heilprin, 1889: 191-201, pl.16].

Pilsbry, H. A. 1889. New and little-known American molluscs. No. 1. Proceedings of the Academy of Natural Sciences of Philadelphia, 41(19): 81-88 [May], 89, pl. 3 [June].

Pilsbry, H. A. 1890a. *Poecilozonites circumfirmatus* var. *corneus*. The Nautilus, 3(8): 95 [January].

Pilsbry, H. A. 1890b. New and little known American mollusks, No. 3. Proceedings of the Academy of Natural Sciences of Philadelphia, 42(20): 296-302, pl. 5 [October].

Pilsbry, H. A. 1891. On *Helix harfordiana* Cooper, and other shells. The Nautilus, 5(4): 39-42, pl. 2 [19 August].

Pilsbry H. A. 1900. The air-breathing mollusks of the Bermudas. Transactions of the Connecticut Academy of Sciences, 10(2): 491-509, pl. 62 [September].

Pilsbry, H. A. 1916-1918. Pupillidae (Gastrocoptinae). Manual of Conchology (Second Series: Pulmonata), 24 (part 93): 1-112, pls. 1-13 [December 1916]; (part 94): 113-176, pls. 14-29 [July 1917]; (part 95): 177-256, pls. 30-38 [November 1917]: (part 96): 257-380, i-xii, pls. 39-49 [April 1918].

Pilsbry, H. A. 1919. Pupillidae (Gastrocoptinae, Vertigininae). Manual of Conchology (Second Series: Pulmonata), 25 (part 98): 65-144, pls. 6-10 [February]; 25 (part 99): 145-224, pls. 11-18 [June].

Pilsbry, H. A. 1924. Recent and fossil Bermudian snails of the genus *Poecilozonites*. Proceedings of the Academy of Natural Sciences of Philadelphia, 76: 1-9 [June].

Pilsbry, H. A. 1934. Notes on the fossil land shells from Bermuda. The Nautilus, 48(1): 34.

Pilsbry, H. A. 1939-1948. Land Mollusca of North America (north of Mexico). The Academy of Natural Sciences of Philadelphia Monographs, 3, volume 1(1): i-xvii, 1-573, i-ix [December 1939]; 1(2): i-viii, 575-994, i-ix [August 1940]; 2(1): frontispiece, i-vi, 1-520 [December 1946]; 2(2): i-xlvii, 521-1113 [March 1948].

Pilsbry, H. A. & J. H. Ferriss. 1906. Mollusca of the southwestern states. II. Proceedings of the Academy of Natural Sciences of Philadelphia, 58: 123-175, pls. 5-9 [June].

Pilsbry, H. A. & E. G. Vanatta. 1909. A new land shell from Bermuda. The Nautilus, 23(5): 63-64 [October].

Pilsbry, H. A. & E. G. Vanatta 1924. *Polygyra appressa linguifera* and *sancta georgiensis*. The Nautilus, 38(1): 4-6 [July].

Poey, F. 1851. Memorias sobre la historia natural de la isla de Cuba, acompañadas de sumarios latinos y extractos en frances. Havana, Viuda de Barcina. Vol. 1: 1-461 pp., pls. 1-34.

Pokryszko, B. M. 1987. On the aphally in the Vertiginidae (Gastropoda: Pulmonata: Orthurethra). Journal of Conchology, 32: 365-375

Preston, H. B. 1910. Additions to the non-marine molluscan fauna of British and German East Africa and Lake Albert Edward. The Annals and Magazine of Natural History, (8)6: 526-536, pls. 7-9.

Prime, T. 1853. List of shells and corals collected at Bermuda, by Temple Prince [*sic*], L.L.B. of New York. 1852. The Bermuda Pocket Almanack for 1853, p. 55.

Proschwitz, T. von. 1983. Växthussnäckan *Hawaiia minuscula* (Binney) funnen i Sverige, samt något om tänkbara efterföljare. Fauna och flora, 78(6): 277-284.

Proschwitz, T. von. 1994. *Lamellaxis clavulinus* (Potiez & Michaud) as a greenhouse species in Sweden. Journal of Conchology, 35(2): 184-185.

Pulteney, R. 1799. Catalogues of the birds, shells, and some of the more rare plants of Dorsetshire. From the new ... edition of Hutchin's history of that county. 92 pp. London.

Rang, S. 1831. Description des coquilles terrestres recueillies pendant un voyage à la côte occidentale d'Afrique, et au Brésil. Annales des Sciences Naturelles, 24: 5-63, pl. 3 [September].

Redfield, J. H. 1853. Descriptions of new species of Helicidae. Annals of the Lyceum of Natural History of New York, 6(4): 14-18.

Reeve, L. A. 1851-1854. Conchologia iconica: or, illustrations of the shells of molluscous animals. Vol. VII. Containing a monograph of the genus *Helix*. L. Reeve, London. 210 pls. + unpaginated text [see Cowie, 1998, for dates of individual plates].

Rein, [J. J.] 1867. Bermuda shells. The Bermuda Pocket Almanack for 1867, pp. 75-77.

Richardson, L. 1986. Polygyracea: catalog of species (Part 3, Sagdidae). Tryonia, 13: 1-38.

Richardson, C. L. 1988. Streptaxacea: catalog of species. Part I Streptaxidae. Tryonia, 16: i, 1-326.

Riedel, A. 1980. Genera zonitidarum - Diagnosen supraspezifischer Taxa der Familie Zonitidae (Gastropoda, Stylommatophora). W. Backhuys, Rotterdam, 197 pp. incl. 2 pls.

Robinson, D. G. 1999. Alien invasions: the effects of the global economy on non-marine gastropod introductions into the United States. Malacologia, 41(2): 413-438.

[Say, T.] 1816. Conchology. p. [1-15], pls. 1-4. In: Nicholson, W., ed., American edition of the British Encyclopedia, or dictionary of arts and sciences, comprising an accurate and popular view of the present improved state of human knowledge. Volume IV. Mitchell, Ames & White, Philadelphia. [not seen]

Say, T. 1821. Descriptions of univalve shells of the United States. Journal of the Academy of Natural Sciences of Philadelphia, 1(1): 149-179.

Say, T. 1822. Descriptions of univalve terrestrial and fluviatile shells of the United States. Journal of the Academy of Natural Sciences of Philadelphia, 2(2): 370-381.

Say, T. 1825. Descriptions of some new species of fresh water and land shells of the United States. Journal of the Academy of Natural Sciences of Philadelphia, 5(1): 119-131.

Schileyko, A. A. & H. P. M. G. Menkhorst. 1997. Composition and phylogenetic relations of the Cochlicellidae (Gastropoda, Pulmonata). Ruthenica, 7(1): 51-60.

Seddon, M. B. & D. T. Holyoak. 1993. Land Gastropoda of NW. Africa: New distributional data and nomenclature. Journal of Conchology, 34(5): 321-331.

Sheppard, R. 1823. Description of seven new British fresh-water shells, with observations upon many other species. Transactions of the Linnean Society of London, 14: 148-170.

Sherborn, C. D. & B. B. Woodward. 1901. On the dates of publication of the 'Histoire naturelle générale et particulière des mollusques terrestres et fluviatiles' and the 'Tableaux systématiques des animaux mollusques,' by the Barons Férussac and G. P. Deshayes. The Annals and Magazine of Natural History, (7)8: 74-76.

Shuttleworth, R. J. 1853. Diagnosen neuer Mollusken. No. 5. Critische Beleuchtung der zur Gruppe *Sagda* Beck, Albers gehörenden westindischen Heliceen. Berner Mittheilungen, Dec. 1853: 297-335.

Shuttleworth, R. J. 1854. Diagnosen neuer Mollusken. No. 6. Beiträge zur näheren Kenntniss der Land- und Süsswasser-Mollusken der Insel Portorico. Berner Mittheilungen, Mar. 1854: 33-56.

Sierwald, P. 1988. Spiders of Bermuda. Nemouria, Occasional Papers of the Delaware Museum of Natural History, 31: 1-24.

Simmonds, F. J. & I. W. Hughes. 1963. Biological control of snails exerted by *Euglandina rosea* (Férussac) in Bermuda. Entomophaga, 8(3): 219-222.

Smith, B. J. & J. Stanisic. 1998. Pulmonata. Pp 1037-1125 in Beesley, P.L., G. J. B. Ross, & A. Wells (eds.), Mollusca: The southern synthesis. Fauna of Australia. Vol. 5. CSIRO Publishing: Melbourne.

Smith, E. A. 1884. An account of the land and freshwater Mollusca collected during the voyage of the 'Challenger' from December 1872 to May 1876. Proceedings of the Scientific Meetings of the Zoological Society of London, 52(18-19): 258-281, pls. 22, 23.

Smith, E. A. 1894. A list of the land and fresh-water Mollusca collected by Dr. J. W. Gregory in East Africa during his expedition to Mount Kenia, with descriptions of a few new species. Proceedings of the Malacological Society of London, 1(4): 163-168 [25 October].

Smith, H. H. 1912. *Rumina decollata* in Mobile and New Orleans. The Nautilus, 6(1): 4-6.

Solem, A. 1964. New records of New Caledonian nonmarine mollusks and an analysis of the introduced mollusks. Pacific Science, 18(2): 130-137.

Solem, A. 1974. Island size and species diversity in Pacific Island land snails. Malacologia 14 ("1973"; Proceedings of the Fourth European Malacological Congress): 397-400.

Solem, A. 1989. Non-camaenid land snails of the Kimberley and Northern Territory, Australia. I. Systematics, affinities and ranges. Invertebrate Taxonomy, 2(4)(1988): 455-604 [22 March].

Solem, A. 1990. Limitations of equilibrium theory in relation to land snails. International Symposium on Biogeographical Aspects of Insularity (Rome, 18-22 May 1987). Atti dei Convegni Lincei, 85: 97-116.

Spix, J. B. 1827. Testacea fluviatilia quae in itinere per Brasiliam annis MDCCCXVII - MDCCCXX jussu et auspiciis Maximiliani Josephi I. Bavariae regis augustissimi ... Digessit, descripsit et observationibus illustravit Dr. J. A. Wagner. C. Wolf, Munich. pp. [i-iii] iv, 1-36 (text), [i-ii] (plate explanations), pls. 1-29.

Sterki, V. 1893. Observations on *Vallonia*. Proceedings of the Academy of Natural Sciences of Philadelphia, 1893: 234-279, pl. 8.

Thiele, J. 1929-31. Handbuch der systematischen Weichtierkunde. Vol. 1. 778 pp.; Gustav Fischer, Jena. [Part 1 (Loricata; Gastropoda: Prosobranchia): 1-376, September or October 1929; Part 2 (Gastropoda: Opisthobranchia and

Pulmonata; additions; index for parts 1 and 2): 377-778, before November 1931].

Tomlin, J. R. le B. 1932. A supposed new *Succinea* from Bermuda. Proceedings of the Malacological Society of London, 20(2): 98-100, pl. 9A.

Tristram, H. B. 1861. Catalogue of a collection of mollusks from Bermuda. Proceedings of the Zoological Society of London, 1861: 403-405.

Tryon, G. W. 1887. Manual of Conchology; structural and systematic. With illustrations of the species. Second series: Pulmonata, Vol. 3 (Helicidae: Vol. 1): G. W. Tryon, Philadelphia; pp. 1-313, pls. 1-63.

Turgeon, D. D., J. F. Quinn, Jr., A. E. Bogan, E. V. Coan, F. G. Hochberg, W. G. Lyons, P. M. Mikkelsen, R. J. Neves, C. F. E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F. G. Thompson, M. Vecchione, & J. D. Williams. 1998. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Mollusks, 2nd ed. American Fisheries Society, Special Publication 26, Bethesda, Maryland, 526 pp.

[UC-IPM] University of California, Statewide Integrated Pest Management Project. UC Pest Management Guidelines. Citrus – Brown Garden Snail. Web Site <http://axp.ipm.ucdavis.edu/PMG/r107500111.html> [update 5/99; last viewed February 2000].

Vanatta, E. G. 1911. Bermuda shells. Proceedings of the Academy of Natural Sciences of Philadelphia, 62: 664-672 ["Dec., 1910"; published January 1911].

Vanatta, E. G. 1912. Bermuda shells. The Nautilus, 26(1): 12.

Vanatta, E. G. 1923. Bermuda shells. The Nautilus, 37(1): 32-33.

Vanatta, E. G. 1924. Land shells of Admiral's Cave, Bermuda. The Nautilus, 38(1): 6-7 [July].

Vanatta, E. G. 1925. Four new species of shells. Proceedings of the Academy of Natural Sciences of Philadelphia, 76(1924): 423-425 [February 1925].

van der Schalie, H. 1948. The land and fresh-water mollusks of Puerto Rico. Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 70: 1-134, pls. 1-14.

Verrill, A. E. 1902. The Bermuda Islands: their scenery, climate, productions, physiography, natural history, and geology; with sketches of their early history and the changes due to man. Transactions of the Connecticut Academy of Arts and Sciences, 11(2) (1901-1902): 413-896, pls. 65-104 ["Introduction of land snails and slugs," pp. 727-735; see also Verrill, 1903].

Verrill, A. E. 1903. The Bermuda Islands: lists of figures in the text; explanation of plates; index; contents. Transactions of the Connecticut Academy of Arts and Sciences, 11(2): 897-957, v-x [February 1903; *teste* Ferguson *et al.*, 1991].

Verrill, A. E. 1905-1907. The Bermuda Islands. Part IV. – Geology and Paleontology, and Part V. – An account of the coral reefs. Transactions of the

Connecticut Academy of Arts and Sciences, 12 (1904-1907): 4-92 (June 1905), 93-140 (Nov. 1905), 141-188 (Feb. 1906), 189-236 (Mar. 1906), 237-284 (Apr. 1906), 285- 300 (June 1906), 301-332 (Mar. 1907), 333-348 (May 1907) 348, pls. 16-40 ["Land shells," pp. 158-172].

Wagner, A. 1911. Die Familie der Helicinidae [Section 2]. Neue Folge. Systematisches Conchylien-Cabinet von Martini und Chemnitz, Band 1, Abtheilung 18, Theil 1, Lieferung 547: 329-391, pls. 67-70 [May].

Wallace, A. R. 1895. Island life; or the phenomena and causes of insular faunas and floras, including a revision and attempted solution of the problem of geological climates. Second and revised edition. London, MacMillan and Co.; xx + 563 pp.

Wiktor, A. 2000. Agriolimacidae (Gastropoda: Pulmonata) – a systematic monograph. Annales Zoologici, 49(4): 347-590.

Woodley, N. E. & D. J. Hilburn. 1994. The Diptera of Bermuda. Contributions of the American Entomological Institute, 28(2): 1-64.

Zilch, A. 1959-1960. Gastropoda von Wilhelm Wenz. Teil 2. Euthyneura. Handbuch der Paläozoologie (O. H. Schindewolf, ed.), 6(2): i-xii, 1-835. Borntraeger, Berlin [pp. 1-200, 17 July 1959; 201-400, 25 November 1959; 401-600, 30 March 1960; 601-835, i-xii, 15 August 1960].